RESIDENTIAL HOUSING MARKETS

BEFORE AND AFTER LAND USE CHANGES

A Dissertation

by

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ABSTRACT

This study expands the existing literature on impact of environmental amenities and disamenities on the value of single family housing by temporally and spatially examining changes in the effect of nature and industry. The study area is bounded by a forest, a portion of which has been designated as a nature preserve and another portion had been sites for oil wells until 1993 and have transformed into a nature preserve. Using a comprehensive dataset of market price from sales transactions collected over a period of twenty-eight years, this study examined the changes in the impact of nature preserve and industrial site in the City of Whittier, CA before and after the conversion. The data was collected from 1986, when all oil wells sites were considered active, until the most recent sales transaction data in 2013. This study compares the impact in a series of fourteen two year periods. The 28 year study period includes four periods before the conversion and ten periods after the conversion. This structure allows for before-and-after comparison of the impact of the conversion on itself and near amenities in regards to housing sales prices. The spatial hedonic models in series of longitudinal analyses assisted to compare the effects of transformation and examine the recovery process over time across space.

The result revealed that it took 10 years for the former oil wells site to recover its positive association to near single family homes as an amenity. There was an initial increase of positive association between the site and the sales price of single family houses upon the conversion. In contrast, positive association between the nature preserve

and nearby properties had constantly decreased since the conversion. After 10 years from the conversion, the positive impact of the former oil well sites surpassed the positive impact of the neighboring never-developed nature preserve. Recovery of use value and expectation of the residents accounts for the initial increase and recovery of non-use value and changes in the residents' perception accounts for the later increase, which took 10 years after the conversion.

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CHAPTER I

INTRODUCTION

1.1 Problem Statement

Hedonic models cannot capture the impact of long-term subtle changes associated with improved or reduced environmental quality because residents can only perceive differences in amenities and their consequences for a short period of time (Freeman Iii, 2003). Since it uses present levels of the amenities in the calculation, people might wrongly expect future intrinsic and instrumental value of those amenities and fail to account for potential changes, such as policy changes on public lands, potential development on privately owned open space, or change in peoples' perception on amenities. While these changes impact integral part of hedonic model, the conditions of the properties, substantially, previous literature has failed to examine the changes in the impact in time (McConnell & Walls, 2005). To fill the gap, this dissertation will examine the changes in the impact of natural amenity and industrial site on residential property value over 28 years which includes before and after the conversion of the industrial site into natural amenity.

Incorporating natural amenities into the physical place enhances not only the attractiveness of the place, but also the wellbeing of the people that live there. Some of the examples of amenities are wilderness land, conservation land, water resources, and social and cultural traditions (Bertrand, Duflo, & Mullainathan, 2002). Such amenities are location-specific and non-market input goods that enter residents' utility functions

(Nichols, Oliner, & Mulhall, 2010). These amenities are believed to attract migrants seeking a place with rich amenities because recreational and aesthetic utilities of natural amenities are more likely to be perceived as critical (Meyer, 1994). To quantitatively examine those preferences, hedonic price studies have attempted to examine the proximity effect of amenities on property values nearby. For example, Thorsnes (2002) examined the effect of a nature preserve on building lot prices in three subdivisions in Grand Rapids, Michigan. The author used sales data collected by Tax Assessor's Office over 30 years. The result reveals positive associations between proximity to an amenity and monetary value of property. Numerous other hedonic studies regarding natural amenities and property values have also shown the positive association among them (Bolitzer & Netusil, 2000; Brander & Koetse, 2011; S.-H. Cho, Poudyal, & Roberts, 2008; Crompton, 2005; Garrod & Willis, 1992; J. Geoghegan, Lynch, & Bucholtz, 2003; Mansfield, Pattanayak, McDow, McDonald, & Halpin, 2005; Neumann, Boyle, & Bell, 2009; Rosen, 1974; Saphores & Li, 2011; Tyrväinen, 1997; Tyrväinen & Miettinen, 2000).

On the other hand, the number of studies analyzing proximity effect of industries on residential value has been minimal. Among those, some of the studies have focused on oil and gas wells and refineries (Boxall, Chan, & McMillan, 2005; Flower & Ragas, 1994; Grislain-Letrémy & Katossky, 2014; Muehlenbachs, Spiller, & Timmins, 2014). Flower and Ragas (1994) examined the negative impact of oil refineries on single-family property value in St. Bernard Parish, LA. Boxall et al. (2005) focused on oil and gas production facilities, mainly wells, near rural residential area in Central Alberta, Canada.

Both studies found that proximity to such industrial sites decreased the value of residential properties. Specifically, Flower and Ragas (1994) found that the negative impact had intensified after discloser of the studies relating a statistical link between industrial pollution and the high incidence of cancer. It partially suggests how residents' perception of such facilities plays a role in the value of nearby properties. The authors captured the changes in effect by looking at the market in three different time periods. A negative influence was revealed during all years of the study, as well as additional reduction in value following the change in environmental awareness.

As evinced from the literature, natural amenities have positive effect on residential properties whereas industrial sites prove otherwise. Communities often have compromised when promoting either economic development or preserving nature. The goal of community development is to increase the quality and quantity of economic and social well-being in a specific area (O'Sullivan, 2003). In the process of such development, communities are often faced with trade-offs between industrial development and preservation of nature. Balancing nature and industry is an on-going problem in local communities. While industrial development provides economic opportunities (e.g., jobs) natural amenities contribute to the underlying value of the place. It is important to understand the impact those decisions regarding industry and nature has on the communities and the value of properties therein.

1.2 Research Objectives

The main objective of this study is to examine the relationship between changes in environmental dis/amenities and economic impact in terms of property value in a long term period of time. This study uses a longitudinal hedonic price model to analyze housing prices around oil well sites and nature preserves both before and after the removal of oil wells. The study utilizes a comprehensive dataset that includes parcel data and corresponding sales prices of housing transactions over a 28 year period. The study incorporates detailed GIS analysis with econometric models (i.e. fixed-effects and spatial regression models) in order to obtain unbiased estimates of model coefficients.

The specific objectives of this study are:

1. To examine the extent to which nature preserves impact nearby single family home sales prices
2. To examine the extent to which industrial sites impact nearby single family home sales prices
3. To examine changes in the impact of nature preserves on residential properties when an adjacent industrial site transforms into a nature preserve
4. To examine whether the impact of a nature preserve when it co-existed with oil wells is different from the impact of the nature preserve when taken separately
5. To examine how long it takes to recover the positive association of nature since the oil wells were removed and recovered as a nature preserve.

1.3 Significance of the Study

While literature on natural amenities and industrial sites is rich and varied, prior research that examines the transition of natural and industrial amenities in the same place as one replaces the other have not been identified. This study simultaneously examines the impact of industrial and natural sites/amenities on the value of residential properties. The research specifically examines Whittier, CA using hedonic pricing during the period that includes the transition of adjacent properties from multiple industrial sites to a nature preserve.

The result of this study provides critical information for planners and policy makers regarding issues of preservation and development. The State of California decided to purchase those oil well sites for preservation purposes when the companies were not making enough profit. Now with advanced technologies and higher oil price, the companies are seeking to reopen those sites and the City Council is supporting it for the tax and economic opportunities. However, what is often missing during deliberations is the impact of such transitions on the value of residential properties in the city. Comparison of the impacts over a long term period provides enhanced perspectives on the benefits and costs not only for residents but also for decision makers. In this sense, the result of this research can add to the process of projecting property values and making policies.

1.4 Dissertation Outline

The dissertation consists of seven chapters. Chapter I introduces research problems, objectives, and the significance of the study. Chapter II reviews several areas of literature including environmental valuation, hedonic price model, and GIS. In the hedonic price model section, a comprehensive review of basic concepts, theories, assumptions, and limitations are discussed. In addition, empirical hedonic housing studies on the amenity and disamenity effects of both natural and industrial sites are reviewed. Chapter III discusses the theories and hypotheses in this study. Chapter IV describes the research design, methods, and data employed in this study. It elaborates the study area and condition and presents data sources and the data treatment, followed by variable selection. Chapter V lays out the descriptive statistics of variables, and the process by which the hedonic model is specified. An overall hedonic model is specified to understand the general impact of the nature preserve and the industrial site on housing price in the study area. Chapter VI presents hedonic models in subsets of time periods to investigate how the impact of the nature preserves and the formal industrial site on the value of residential properties changes. Chapter VII summarizes major findings and conclusions from the study. This Chapter also presents the contributions and policy implications of the study. The research limitations and recommendations for future studies are suggested.

CHAPTER II

LITERATURE REVIEW

This research rests on the foundation of five bodies of literature reviewed in this chapter. The review begins with environmental valuation. It explains the importance of environmental valuation and summarizes various types of measures for environmental valuation. Among those valuation methods, hedonic price model is reviewed in the second section. General understanding, requirements, and limitations of hedonic modelling are studied. Following the general understanding of the hedonic price model, empirical hedonic housing studies on nature preserves and industrial sites are introduced in following two sections. GIS related hedonic literature is reviewed at the last section of the literature review.

2.1 Environmental Valuation

2.1.1 Valuation of Environment

The importance of natural ecosystem has been repeatedly emphasized by planners, decision makers, researchers, and even residents of places. It is not overstating to say that the existence of our societies depend on the services of natural ecosystems. Given the importance of nature, it is almost impossible to economically value the natural ecosystems in dollar terms. Despite its difficulty and controversy, economists and environmentalists have attempted to value ecosystem and its services in order to set priorities and order in decision making processes.

One of the reasons economic valuation of ecosystem is challenging is that economics is more concerned with prices than with values or importance. Price of a good does not comprehensively reflect its importance, which also includes social and philosophical aspects. Resources of great importance to human beings might not be valued as high as it should be. Most jewellery is priced higher than water or even air. It is not its importance or real value that determines the price. The price is determined by supply and demand. In many cases, the abundance of resources has kept prices so low that there are no markets and thus no prices (Heal, 2000). Nonetheless, environmental valuation attempts to estimate the economic value of non-market natural resources reveal, at least partially, their fundamental importance. The difficulty in capturing the economic value of resources comes from their non-rival and/or non-excludable characteristics, which is usually caused by inefficient and uncritical allocation in markets. Drinking water and fresh air is provided for everyone and one person's use of such resource in a neighborhood does not diminish another person's use, non-rival. Also, once the quality of such resources is improved, every member will enjoy the same level of quality, non-excludable (Loomis, 2000). Some resources are valued at high prices due to need. However, the proportion of resources that are being valued in the market is extremely small compared to what services the ecosystem provides. To capture the value of ecosystem services a variety of types of measures , especially for non-market valuation, have been developed (Costanza et al., 1997).

Environmental valuation may be categorized based on the method users' preference is measured, revealed or stated. Revealed preference methods analyze choices made by individuals while stated preference methods use data from people's responses to hypothetical questions. Revealed preference methods include *Travel Cost Method* and *Hedonic Pricing Model.* Stated preference methods include *Contingent Valuation Method, Contingent Experiment Choice and Conjoint, Analytic hierarchy process, and Cost-based Methods.* The methods are reviewed in appendix i.

2.2 Hedonic Pricing Model

Lancaster (1966) first started the idea of consumers' maximization of utility from the attributes embodied in products, and Rosen (1974) applied the idea with "hedonic prices" stating as "Observed product prices and the specific amounts of characteristics associated with each good define a set of implicit or "hedonic" prices" (Rosen, 1974, p. 34). The hedonic price model is based on the interaction between bid functions of households, individuals' preferences, and offer functions of suppliers (Rosen, 1974). The model establishes a functional relationship between characteristics of a property and the observed value of the property. The price of any attribute is referred as the equilibrium marginal implicit price of the attribute, market premium to be paid for one more level of the attribute (Can, 1992). Number of studies has shown that any attributes surrounding the property such as air quality (Anselin & Le Gallo, 2006; Harrison & Rubinfeld, 1978), open space (Anderson & West, 2006; Lutzenhiser & Netusil, 2001) , land-use

(Jacqueline Geoghegan, Wainger, & Bockstael, 1997) (Gayatri Acharya & Lynne Lewis Bennett, 2001), landfill (Deaton & Hoehn, 2004; Ketkar, 1992), hazardous sites (De Vor & de Groot, 2011; S. W. Hamilton & Schwann, 1995; Li & Saphores, 2012), etc., could hold the marginal implicit prices, indicating the marginal economic benefit or loss for small changes in those attributes.

According to the standard hedonic framework (Rosen, 1974), a Hedonic Price Model explains the market price (P) of a single family house based on its structural (S) and neighborhood (N) characteristics, and locational attributes (L):

$$\mathrm{P(h)} = \mathrm{f}(\mathrm{S_h}, \mathrm{N_h}, \mathrm{L_h}, \beta, \delta, \gamma) + \varepsilon$$

Where P(h), S, N, and L are vectors; $\beta, \delta,$ and γ are associated parameter vectors; and ε is an error term associated with uncertainty in the measurement of variables, unexplained variables, and the personal preferences of homebuyers. The partial derivative of the function represents the implicit price for each characteristic or attribute, a consumer's marginal willingness to pay.

2.2.1 Explanatory Variables

Structural characteristics of a single family house refer to the physical features of the property including both the land and the building. A house comprised of physical features that are relevant to the value of the property. The relevant factors include size of lot, house, backyard, and front yard; numbers of rooms, bathrooms; existence of garages, fireplaces, hot tubs, and swimming pools; age and condition of the house and etc.

(Bolitzer & Netusil, 2000; Crompton, 2005; J. Geoghegan et al., 2003; Rosen, 1974)

Neighborhood characteristics can be dealt in two different levels of scales, neighborhood conditions and community conditions. Relevant factors of local neighborhood conditions to property values includes the quality and condition of neighboring houses and streets, socio-economic characteristics including density, population, income level, and neighborhood crime rates. On the other hand, there are factors that influences over larger areas than a neighborhood unit. Relevant factors of community conditions refer to policies and local public service provisions that vary across larger areas. The conditions may include school district, and rates of taxation. (Anderson & West, 2006; S. H. Cho, Lambert, Kim, Roberts, & Park, 2011; Donovan & Butry, 2011)

Locational attributes relate to conditions regarding the proximity, accessibility, and/or view of amenities or disamenities. It is assumed that people will pay a premium for a location proximate to amenities and pay less for a location proximate to undesirable facilities. Depending on the study area, relevant dis/amenities include parks, nature preserves, wetlands, work place, schools, the city center or central business district (CBD), train stations, major highways, power lines, and others that have impact on people's preference by their existence. Locational attributes can also be accounted for with environmental attributes such as noise and pollution, which will have strong correlation with physical places like highways, airports, and waste lands. Because of this relationship, some of the dis/amenities have mixed impact of locational advantages, and environmental disadvantages. For instance, residents near highway interchanges will enjoy easier access to the highway while suffering from the noise and pollution generated by traffic. (Bastian, McLeod, Germino, Reiners, & Blasko, 2002; Neumann et al., 2009; Tapsuwan, Ingram, Burton, & Brennan, 2009)

Using above characteristics and attributes of a property and surrounding environment, researchers attempt to explain the marginal implicit value of each characteristic and attribute of a property and eventually value of surrounding amenities or disamenities, in many cases environmental resources. In order to provide more reliable estimates, Rosen (1974) required strong assumptions; (1) market equilibrium; (2) perfect competition and continuum of products in the market; and (3) complete information about property characteristics and attributes available to both buyers and sellers.

2.2.2 Market Equilibrium

Rosen (1974) explains market equilibrium as characteristics of a market formed with function of profit-maximizing producers and utility-maximizing consumers. It is required that households have comprehensive information on all housing prices and attributes. This implies that homebuyers are fully aware of property prices of alternative conditions and locations and make most reasonable choices. In an efficiently operating housing market, both buyers and sellers share comprehensive knowledge of related properties in terms of its structural, neighborhood, locational, and environmental attributes (Freeman Iii, 2003; Hanley, 1992; McConnell & Walls, 2005). In addition to the availability of knowledge, it is also required that the market adjusts price of houses instantaneously to respond to changes in either demand or supply (Freeman Iii, 2003). Delay in adjustment of prices might provide inaccurate information for profit-maximizing buyers or utility-maximizing sellers and cause biased decision in selecting the property. Along with full knowledge provided to actors, and prompt adjustment of prices in response to supply and demand changes, sufficient variation within each attribute in the market is required in order to reach market equilibrium. It is critical that the full range of attribute choices is offered for home buyers to search their options in different sets and composition of attributes that reflects their preferences among different attributes.

The assumptions above require conditions which may not be possible in a real market. The speed of adjustment of the prices in response to the changed conditions of supply and demand may not be as prompt as it should be. Also, knowledge that buyers and sellers have regarding the property and its surroundings may be limited. When buyers and sellers are not fully aware of the information and price adjustment, the market may be in disequilibrium (McConnell & Walls, 2005). Another assumption that requires sufficient variation within each attribute may not be satisfied due to limited range of choices in housing market. The implicit price function is continuous when a full range of houses with varying attributes is available in the market. However, in most cases, buyers are not provided with full range of options, which thus, prevents utility-maximization. This means that buyers are bound to choose houses that may not provide the greatest possible utility. In addition to the issues related to the assumptions, there is one issue that is related to limited information on a property and surrounding's attributes. In hedonic price model, a house's price, the net present value of the asset, reflects expectations about future amenity levels. Future amenity level, however, is not guaranteed by the present levels of the amenities. Buyers and sellers might expect an inaccurate picture of future amenities and thus produce biased valuation of properties. For example, there might be policy changes on public lands and potential development on privately owned open space, which can change the conditions of the properties substantially (McConnell & Walls, 2005).

Despite the issues addressed, some studies provide grounds to assume market equilibrium in hedonic price models unless the housing market suffered from severe shocks since housing markets adjust quickly to small shock (Maclennan, 1977). In addition, Bajari and Benkard (2005) showed that even under imperfect competition and with small sample number of properties, a function relating price and product characteristics exists.

2.2.3 Market Segmentation

Housing market is composed of many separate submarkets which need to be separately estimated. Structure of demand and that of supply are different across submarkets. Difference in structure of demand and supply means that the marginal implicit price of characteristics will be different depending on markets, which then, will require different structures of hedonic model to estimate (Freeman Iii, 2003). J. Geoghegan et al. (2003) showed different marginal implicit prices for open spaces across different counties in Maryland and Anderson and West (2006) also obtained contrasting valuation structure for urban and suburban residential properties. Thus, the extent of the market under study should be a single market for housing services with relatively homogenous properties within well-defined geographic units. Relatively compact and homogenous study sites have greater chance to possess homogenous demand and supply structure, deriving more reliable marginal implicit values for the various intrinsic and environmental attributes of each house. A single market can be formed by geographical features, desire for homogeneous neighborhoods, and/or physical or administrative boundaries. On the buyers' side lack of information could also set a barrier to mobility among submarkets (Freeman Iii, 2003).

2.2.4 Functional Form

Functional form decides on the manner of interaction among independent variables to determine the level of dependent variable (Loomis & Walsh, 1997). Functional foams being used in Hedonic Price models include the linear, log-log, log-linear, quadratic, and the Box-Cox transformation. Despite the utilization of various forms in hedonic studies, hedonic price model lacks a firm theoretical basis to support the choice of functional form. There is limited guidance about which functional form is most appropriate, or suggestions of priori or ideal functional form to be applied in a particular model (Halvorsen & Pollakowski, 1981; McConnell & Walls, 2005). The lack of standards leads most researchers to use goodness-of-fit criteria, which is often arbitrary, as a criterion in choosing an appropriate form. Since the form used results in substantial differences in the regression results; however, it is more critical to use a form that most accurately estimates marginal implicit prices for attributes than a form that provides a better fit (Cropper, Leland, & McConnell, 1988; Freeman Iii, 2003; Halvorsen & Pollakowski, 1981).

2.2.4.1 Linear relationship

Linear form is the most direct and simplest functional form for a hedonic price model. The model consists of linear dependent and independent variables without any transformation, which makes the interpretation intuitive and straightforward. The value of the coefficients of the characteristics and attributes can be directly interpreted as its marginal implicit price. For structural characteristics like number of rooms, the coefficient equals the price increase for an increase in number of rooms. Similarly, for coefficients of locational variables like distance to an amenity, it represents that one unit increase in distance is associated with the increase or decrease, the coefficient, in price of the house, holding other variables constant. Interpreting a dummy variable such as "with/without view" is more direct. If the value one means the property has a view, the coefficient represents the monetary value of the view.

It is assumed in the specification of a linear form that the impact of an attribute does not change regarding its quantity or level. It remains constant regardless of its initial starting point. Also, it assumes that the explanatory variables are independent that the marginal implicit price for one attribute is not influenced by other attributes. This is why collinearity problems for linear functions are more critical than those ones for quadratic or Box-Cox functions. Individual coefficients with collinearity may be more unreliable than the ones presented by interaction terms. However, a simple linear hedonic function often times outperforms quadratic or Box-Cox functions when certain variables are omitted, surrogated, or not observed. It simply skips “hard to measure” attributes rather than attempting to make badly biased estimates (Cropper et al., 1988).

2.2.4.2 Non-linear relationship

Unlike the assumptions of independence between explanatory variables in linear functions, in reality, the marginal implicit price of one variable within a house is likely to be dependent on the others. In those cases, we can either create all the possible combinations of dummy variables or introduce interaction terms between related explanatory variables. For the first option, however, the model is likely to create too many variables (Mark & Goldberg, 1988). In addition to the dependency issue, the nature of each variable, not being linear in its effect or outcome, is another important issue in a hedonic price model. Impact of a variable might not be constant throughout its sample range. In other words, the degree or direction of increase or decrease in the price might change for each additional unit of a variable. The impact can be at lesser or greater extent depending on its initial level. For example, being closer to a park by 10m when the property is located at 30m away from the park will have greater impact than it is for a property located at 1000m apart from the park. Also, addition of a room to two bed-room house will have significantly greater impact than those with five or six rooms. These nonlinear relationships can be dealt with different forms of functions consisting of variables transformed with log, quadratic, and/or Box-Cox.

2.2.4.3 Logarithmic functional form

The most used non-linear functional form is a log form, which consists of dependent and/or independent variables transformed with natural log. The log form is usually applied when a variable consists of large integer values such as wages, sales, market values, population, number of employees, and school enrolment. There are two types of log functions commonly used in hedonic models, semi-log, and log-log, which is often termed as log-linear or double-log. Semi-log functions usually take only dependent variables for log transformation and remain independent variables at their original level. On the other hand, log-log functional forms require both the dependent and independent variables to be logarithmically transformed (J.M. Wooldridge, 2009).

Interpretation of those log functional forms requires a different approach from linear models. For semi-log functional forms, log on the dependent variable, the coefficient of an independent variable is interpreted as the percentage changes in dependent variable, usually price, for one unit change in the independent variable, holding other factors constant. This semi-elasticity of dependent variable with respect to independent variable may be interpreted as percentage changes (J.M. Wooldridge, 2009). Similarly, a log-log functional form is interpreted by elasticity of both dependent and independent variables. The coefficients of the independent variable may be interpreted as the percentage changes in the dependent variable for one percent increase in the independent variable. For dummy variables, however, only semi-log form can be used, considering the nature of dummy variable having value of only zero or one. The interpretation of those dummy variables can be the percentage changes in the dependent variable associated with the existence of the attribute.

Like the linear functional forms discussed above, collinearity problems must be addressed when using log functions. Individual coefficients of log function may be unreliable due to collinearity. Also, the function provides relatively accurate estimates when variables are omitted or surrogated (Cropper et al., 1988).

2.2.4.4 Quadratic functional form

Quadratic functional forms are frequently used in hedonic models to capture increasing or decreasing marginal effects. In reality, the coefficients of linear forms that hold constant marginal effects are likely to be limited in explaining relationships of attributes in real life. In many cases, marginal effects rapidly increase or decrease as the variables reach their minimum or maximum level. Quadratic variable is added to incorporate the changes in the magnitude or direction of effects. The marginal effect can sharply increase to reach its peak at some point and diminish gradually after its peak. In such a case, the function would produce a nonlinear, often times, curve line that holds either decreasing or increasing slopes.

In addition to quadratic functions, gamma transformation fits such an increasing or decreasing marginal effects. F. Des Rosiers, Lagana, Thériault, and Beaudoin (1996) applied the gamma transformation to explain price by distance from properties to shopping centers. The study suggested the potential use of gamma function on properties surrounded by parks and golf courses.

The quadratic function produces unfitting marginal prices at extreme values of attributes due to the large spread of the errors. In cases with omitted variables, the quadratic functions produce the largest normalized bias. The poor performances of quadratic forms are due to more number of coefficients that are biased by omitted variables. In contrast, quadratic cases handle collinearity problems better since marginal prices depend on several coefficients. A combination of these coefficients may be more reliable than individual coefficients (Cropper et al., 1988).

2.2.4.5 Box-Cox form

Box-Cox functional form (Box & Cox, 1964) includes a transformation of each dependent and/or independent variable separately. The transformation results in a highly general and flexible functional form unlike previous forms that impose highly restrictive assumptions on the underlying demand and supply functions (Halvorsen & Pollakowski, 1981). The transformation is proposed to reduce anomalies such as non-additivity, non-normality and heteroscedasticity (Sakia, 1992). Box-Cox transformation for nonnegative y, which usually is the case for hedonic models, is defined as

$$Y^{\lambda} = \beta_1 + \beta_2 {X_2}^{\lambda(2)} + \ldots\ldots + \beta_j {X_j}^{\lambda(j)} + \varepsilon$$

$$Y^{\lambda} = \frac{Y^{\lambda} - 1}{\lambda} \;\text{ if } \lambda \neq 0$$

$$= \log Y \;\text{ if } \lambda = 0$$

Where Y is property price, X_j is the attribute variable, and λ is the parameter, possibly vector, which defines particular transformation. Parameter values, λ, based on maximization of nonlinear likelihood function, are measured separately for each variable in order to fit the model best. Thus, individual variables may not have equal value of parameters. As the equation shows, when all the parameters equal one the functional form can be linear. Similarly, when $\lambda = 0$, it becomes log function (Box & Cox, 1964; Lutzenhiser & Netusil, 2001; Jeffrey M. Wooldridge, 1992).

Even though Box-Cox functional form provides theoretically most fitting models that customarily transform and adjust each variable, it is problematic when it comes to interpretation. The coefficients regressed represents the marginal effect on the transformed prices associated with a unit change on the transformed attribute. The implicit marginal prices cannot be interpreted intuitively and often times it is troublesome to infer (Bowen, Mikelbank, & Prestegaard, 2001). Lutzenhiser and Netusil (2001) used Box-Cox transformation in their study of valuing open spaces using home's sale price. In order to calculate the marginal implicit price of each attribute, following equation was applied.

$$(\partial Y/\ \partial X_j)\left\{(1/\lambda)\left[\lambda\left(\alpha+\sum_{j=1}^{j}\beta_j\,\bar{X}_j\right)+1\right]^{\frac{1i}{\lambda}-1}\right\}\lambda\beta_j,$$

Where $\bar{X}_j$ is the mean of attribute j, α is the intercept, and β_j is the estimated coefficient for attribute j. The marginal implicit price of being close to open spaces may not be presented intuitively by coefficients; however, it may still be calculated with the equations like above.

Box-Cox transformations are more flexible than other alternatives. The transformation is based on the premise that the implicit prices of characteristics depend on the levels of other characteristics. It allows for different transformations of each independent variable and often times generate more accurate results. However, the interpretation of such result is difficult and often cloudy even with the interpretation. Also, when variables are omitted the quadratic Box-Cox forms performed poorly due to more bias in coefficients in the more complicated version of the model. (Cropper et al., 1988; Freeman Iii, 2003; McConnell & Walls, 2005).

2.2.5 Limitations of Hedonic Pricing Model

Even with the assumptions satisfied, there still are theoretical limitations in HPM regarding intrinsic values of amenities. The intrinsic value of amenity may be referred to the value of an amenity in its own sake (Vilkka, 1997). A parcel of land may provide utility to a consumer or output for a producer without any effects of local amenities or public goods. The land itself would possess a value in its own right (Cheshire & Sheppard, 1995). In hedonic price model, a house’s price, the net present value of the asset, reflects expectations about future amenity levels. The use and non-use value of future amenity, however, is not guaranteed by the present value of the amenities. This applies same for instrumental value as well. Buyers and sellers might expect an inaccurate picture of future amenities and thus produce biased valuation based on the present price of properties. In short, the method makes use of current condition to make assumptions of future environmental quality level (Hanley, 1992). Since it uses present levels of the amenities in the calculation, people might wrongly expect future intrinsic and instrumental value of those amenities not counting for potential changes. For example, there might be policy changes on public lands, potential development on privately owned open space, or change in peoples' perception on amenities, which can change integral part of hedonic model, the conditions of the properties, substantially (McConnell & Walls, 2005). Similarly, the method cannot capture the impact of long-term subtle changes associated with reduced or improved environmental quality because residents can only perceive differences in amenities and their consequences for a short period of time (Freeman Iii, 2003). Thus, it is likely that residents will not be able to account for the changes in intrinsic and instrumental values of amenities.

In addition, being based on property values of a single market, HPM fails to account for the benefits, which includes use and non-use values, derived by non-local users of a resource, who do not live close to the site (More, Stevens, & Allen, 1988). It is also possible that a distant located resource that impacts on large area including the study site might not be introduced to the model. Thus, economic benefits of remote resources or resources with large service areas cannot comprehensively be computed.

On top of all the issues with intrinsic and instrumental values, hedonic price model cannot fully capture the intrinsic value of an amenity (Freeman Iii, 2003; More, Averill, & Stevens, 1996). It only attempts to partially explain the relative value by examining other values of use and non-use, most closely existence value. By the definition of intrinsic value, intrinsic value is free from the valuer's attitudes, preferences, experience, and etc. Thus, it is extremely difficult to examine intrinsic value by human measure.

2.2.6 Other Statistical Issues

2.2.6.1 Spatially autocorrelated errors

Housing prices are heavily influenced by factors related to spatial location. This means that spatial heterogeneity and spatial dependence are embedded in the process of estimating marginal implicit prices. Proper specifications of hedonic model require researchers to include variables that capture arrangement and relationship of spatial attributes (Bowen et al., 2001). During the process, however, it is impossible to capture every spatial variation in price, which causes spatial correlation of the error terms. There are mainly two causes of spatial autocorrelation problem, omitted variable and measurement error. Omitted variables are often times due to difficulty in observing or obtaining the data and measurement error is due to scale differences between variables. The consequences of spatially autocorrelated errors include biased and inconsistent coefficients measures, intercept term, variance of error terms, and estimator of the standard error (Bowen et al., 2001; McConnell & Walls, 2005).

To deal with spatial autocorrelated errors Irwin (2002) looked into the effect on the estimation results derived based on different assumptions of the spatial relationship of the error terms to examine the extent of the omitted variables problem. On the other hand, Day, Bateman, and Lake (2004) examined the error terms to infer the appropriate spatial relationship.

2.2.6.2 Multicollinearity

In contrast to spatial autocorrelation errors, multicollinearity occurs when highly correlated independent variables are included in the hedonic price model. Multicollinearity may not cause significant problem in overall explanation of the model (R^2) or predicting the dependent variable, since highly correlated variables substantially consist of the same information. However, it is critical for coefficients of independent variables. The relationship between explanatory variables may cloud the measurement of the marginal implicit price for each attribute. The degree and direction of the coefficient, which supposedly represents the relationship between dependent and independent variables, may be wrongly influenced by the relationship among independent variables. As a result, influences for each individual variable to the dependent variable cannot be accurately measured because the influences maybe attributed to other correlated independent variables (J.M. Wooldridge, 2009).

Hedonic price models may present mlticollinearity among independent variables which essentially explains similar aspect of attributes. For instance, number of bedrooms and bathrooms, and size of lot and house of a property are correlated in its structural form. Another example might be location of amenities. Some of amenities may be close or even adjacent to each other. In those cases, it would be impossible to separate the influences of each to the dependent variable.

There are several ways to test for multicollinearity. First, any correlations that exceed ± 0.7, this figure is varied among researchers, on a correlation matrix indicates collinearity. This is a convienient r-value in that suggests that approximately 50% of each variable is accounted for by the other. Second, variance inflation factors, VIF, help identifying mulicollinearity. Collinearity among variables causes the variance and the standard error to inflate. In the light of this, VIF over level of ten may indicate multicollinearity, although some set the level as low as 5 (François Des Rosiers, Thériault, & Villeneuve, 2000). Last, tolerance value for each variable may also indicate multicollinearity. The low tolerance value, which ranges from 1 to 0, means high degree of collinearity (Loomis & Walsh, 1997; J.M. Wooldridge, 2009).

2.2.7 Interpretation Difficulties

When researchers report their result of hedonic studies, they usually present with significant coefficients of related amenities. Those coefficients are interpreted as statistically significant positive or negative impact on property values. However, it does not necessarily mean that the hedonic quality changes are statistically significant. For example, many studies test the null hypothesis that increase or decrease in value associated with change in amenity level does not differ from zero, not the null hypothesis that the change in value associated with the change in amenity level does not differ from an index that has no change in amenity level from the same data. If the null is tested for difference with zero, the test only confirms the rate of increase, not the hedonic quality adjustments, is significant. In other words, when researchers argue that the coefficients are "significant", often times, it means that the rate of increase is positive, not the actual hedonic part of a good (Triplett, 1991). Thus, to reach more accurate measure and interpretation, it is critical to test the null hypothesis for adjusting for quality change, not difference from zero.

Another issue while interpreting hedonic results is generalization of impacts. Hedonic price model uses actual transaction data of each property, not a sample data that can be treated to represent the population. The methods only make use of actual transactions, which makes it impossible to assume the characteristics of random sample. Each property accounted may have special condition that cannot be accounted, or worse, the good portion of data may be biased due to immeasurable causes. Overcoming this partially conflicts with the assumption of market segmentation. The hedonic models require transactions data within homogenous market, which eventually narrows the extent of study area. Noting that large numbers of transactions may partially help generalization of impacts the result presents within the study area, the model itself possesses inherent limitation. Thus, as stated above, large number of actual data would present some degree of liability in generalization. This suggests that generalization of results is to other situations, or markets, similar to this one—the more similar the more likely to generalize.

Lastly, the causality between levels of amenities and increase or decrease of property prices cannot clearly be proved. Even though, the model attempts to account for every possible variation in attributes, it only explains the correlation between attributes and the price of properties, not the causality. Even with this limitation, hedonic price model with a quasi-experimental design may partially hint on causality between the associations (Kuminoff & Pope, 2009).

Despite the limitations, issues, and assumptions required, the method has been shown to be a legitimate measure to value environmental resources, as F. Des Rosiers et al. (1996) notes “HPM has proven most reliable for establishing the implicit price of individual residential attributes."

2.3 Hedonic Studies: Externalities and Issues in Comparing between Periods

One of the major issues in using temporal variation is the difficulty to account for other contemporaneous variables in addition to the effect of the change from disamenity to amenity. For example, along with the major event, transformation of the oil business to a nature preserve, there may be new developments, household migration, and land use alteration that may affect the conditions of housing market and convolute the structure of the local property valuation. It would be difficult to distinguish the effect of the newly designated nature preserve from above variables. In other words, identifying the net effect of proximity to oil wells or nature preserves, independent variables of interest, would be a difficult task due to potential influence of unobserved externalities.

During the course of a long time span, new development, income change, demographic change, and other factors may shift the baseline of the model. To account for major long term changes in the area requires several measures. These measures, however, may not perfectly control for all the externalities and cause statistical issues during the process of analysis. In reality, it would be impossible to identify and account for all the variation in the price of properties. However, there are some critical and prevalent issues that need to be addressed in the attempt of analyzing property values, such as inflation, regional growth and neighborhood characteristics.

2.3.1 Inflation

Inflation or deflation—accounting for an increase or a decrease of prices of goods and services is essential. For example, Bin, Landry, and Meyer (2009) adjusted the dollar value of each sales transaction, ranges from 1992 to 2002, to December 2002 dollars accounting for inflation. Several other researchers also adjusted the sales transaction into unified dollar value when dealing with relatively long-term time periods in order to estimate more accurate effects of proximity or view of amenities (Neumann et al., 2009; Tapsuwan et al., 2009).

2.3.2 Regional Growth

In addition to the attempt to account for inflation, it is necessary to control for regional growth that may influence the housing market of the area. The common measure to take this into an account is introducing a variable consisting of average residential price of the region that the study area is included or adjacent to into the model. Boxall, Chan, and McMillan (2005), in the study on rural area adjacent to Calgary, included the average residential price of property in the City of Calgary to control for the strong housing market in the region. The authors recognized the considerable increase of house prices in the Calgary market, may influence their subject market, during the time period of the research. Since the city of Whittier is located adjacent to the East Los Angeles area, using average residential price of Los Angeles may be one possible measure to control for regional influence on the site.

Flower and Ragas (1994) applied more sophisticated way of accounting for externalities while examining negative impact of oil refinery on property value in St. Bernard Parish, LA. The authors utilized year of sale data as dummy to create subsets of data for 13 years of time period. They sought to compare the difference in marginal implicit prices of disamenity proximity over 13 years of time period, divided into 3 sub-periods. In order to control for external influences, the author constructed a price index using a hedonic regression on transactions in a control area which consists of properties more than 1.5 miles away from the refineries in St. Bernard. Using the index, sale prices for the data set were adjusted.

Constructing a land or house price index is one way of accounting for external influences, since housing market of larger region that the study area is included may partially represent economic and demographic changes around the region. However, constructing an index is not an easy task. Three basic methods are explained (Case & Shiller, 1987; Palmquist, 1984). The first method is conducting a hedonic regression of near areas like Flower and Ragas (1994) attempted. The method requires a pooled sample of transactions with time dummy variables. The second method applies a series of two-year regressions. The results from those regressions are combined to construct the index. The third method also utilizes hedonic regressions with data of repeat-sale properties. Both second and third method requires relatively large number of transaction data evenly distributed over the area.

Instead of constructing a price index, Tapsuwan et al. (2009) utilized the market growth index to adjust sale prices to control for market growth over time. The market growth index was acquired from the Real Estate Institute of Western Australia. It was critical for the authors to adjust for market growth over time, because the Perth real estate market had experienced exponential demand for houses in the Perth metropolitan area due to the mining boom. The growth was significant over a short period of time for which the influence had to be controlled. In US, which is more relevant to my study, Nichols et al. (2010), in their papers in the Finance and Economics Discussion Series (FEDS) of Federal Reserve Board, Washington, D.C., estimated the land price indexes for the 23 MSAs, composite of residential and commercial/industrial land along with separate indexes for these two broad types of land. Residential land price index for Los

Angeles, the interest area of my study, is also presented. However, it is only provided for 15 years from 1995 to 2010.

2.3.3 Neighborhood Characteristics

For each subset of data, demographic data can be incorporated from census data as neighborhood characteristics (Parmeter & Pope, 2009). The data may be used in hedonic analyses are median house values, percent of population under 18, percent of housing that is owner occupied, and others as needed. However, there is an issue of incorporating census data into parcel level data. It may cause statistical and measurement issues. The data added will be average values of the block group, which will be applied for every property with same value. Otherwise, hierarchical analysis is required to incorporate different levels of datasets. Another issue is that the data in between 10 years is estimated value from interpolation and sample survey. In a quasi-experiment, when variables are entered to account for changes in their value, the data entered should include temporal variation, like changes neighborhood demographics over the time.

There is one important issue that needs to be addressed while dealing with census type data. Incorporating data concerning individual characteristics has other dimensions of issues to consider. In housing studies, mainly focusing on supply and demand, and increase and decrease of housing market, researchers have investigated individual characteristics and their behavior to infer the changes in the market. For example, income is the key variable on which demand depends. On the assumption that people with higher income will spend more on houses, researchers focus on buyers' and sellers' characteristics to examine the market flow. In some of housing studies adopting hedonic concept, researchers have included income level, especially permanent income, in their models to estimate market conditions (Goodman & Kawai, 1982). However, this approach of introducing individual characteristics in hedonic price model studies causes serious problem in every aspect of the study. According to the standard hedonic framework (Rosen, 1974), Hedonic Price Model explains the market price (P) of a single family house based on its structural and neighborhood characteristics, and locational attributes. In this theoretical background, hedonic price model attempts to reveal the marginal implicit price of each attribute related to the house price stated in transaction data by a parcel unit. The individual characteristics of buyer or seller do not determine the monetary value of a property. For example, the monetary value of a single property would not increase whether the resident is a millionaire or not. It is the attributes stated above that determines the price of the property. It is possible that the buyer's income level is high and he/she is generous in spending. Then, this could impact the sales price in a sense. However, this assumption is also against the theoretical assumption of the hedonic model that consumers maximize their utility in market equilibrium. In this regard, attempts to incorporate buyers' and sellers' individual characteristic in the hedonic model would violate the theoretical frame work needed for hedonic analysis. Nonetheless, attempts to incorporate income level or other individual characteristics aggregated in groups as neighborhood characteristics is still a possibility to account for neighborhood attributes, e.g. properties in rich and prestigious neighborhood holds premium for properties in the area.

2.3.4 Research Design with Time Periods of Before and After

As mentioned earlier, distinguishing the effect of the change in amenity from other variables that might occur together or in other times is often difficult in hedonic models using temporal variation. Most efficient and undisputable way to deal with the issue is to conduct a perfect experimental research, in which every variable is observed and controlled, and independent variable of interest changes as intended. In such a case, there would be no external factors to adjust for. However, in a real world, such a research design is impossible. Researchers can only attempt to find cases that encompasses both controlled and uncontrolled group under similar conditions. Quasi-experimental approach to examine before and after effect would partially serve above goal of controlling for externalities. In case of hedonic models, the study would require one area with an amenity and the other without the amenity in a single market. By examining and comparing the outcome of both groups under the same contemporaneous influences, before and after impact in time and space may be evaluated without addressing the issue of contemporaneous variables (Meyer, 1994).

There are several hedonic studies that have utilized Quasi-experimental settings. In the study of impact of riparian buffers on property values, Bin et al. (2009) conducted a quasi-experimental study to examine net effect of newly introduced policy that secures more buffer zones. In this study, the area imposed with buffer rule after July 1997 was compared with a comparison area consisting of nonriparian properties. Both areas experienced some or all the contemporaneous influences under a similar condition. Temporal factors were accounted by collecting data on property transactions for the time period before and after the imposition of the buffer rule for both areas. By comparing before and after buffer rule, the authors could acquire the net effect. The authors also introduced the year fixed effects to adjust for unobserved annual shocks such as new development, inflation, and others. One of the key assumptions in this research design was that "macroeconomic, regional, and local factors affecting property values have an equivalent influence von riparian and nonriparian properties, nonriparian properties serve as a control group in isolating the net effect of the buffer rule on riparian properties." (Bin et al., 2009). In other words, by applying Quasi-experimental design, the authors did not put extra effort to account for macroeconomic, regional, and local factors affecting property values (Meyer, 1994).

2.3.5 Others

Fixed effects technique is largely used to deal with omitted variables bias, often due to unexpected externalities. There are innumerable factors that co-determine the price of a property, and many of these factors are unobservable. If any of the unobserved factors are also correlated with included factors, then it results in bias. Thus, omitted variables bias due to unobservable nature, unexpected events, or subtle or massive changes over time is a major concern in hedonic studies.

In a fixed effect technique, large series of dummy variables are included usually by a spatial or temporal range. Each variable captures the effects of unobserved factors that are constant or similar across the geographic or temporal scale as the fixed effect.

For instance, if homes in a particular area are especially attractive because of some unobservable factor, then the fixed effects can be applied for the zone they belong. Similarly, unobserved factors and unexpected event occurred in certain periods of time can be accounted by the dummy variable that compares with other periods of time (Heintzelman & Tuttle, 2012). Controlling for these fixed effects often results in different outcomes from the models without the treatment. Bui and Mayer (2003) shows the difference a fixed effect approach makes compared to a cross-sectional hedonic regression without accounting for externalities and Redfearn (2009) and Pope (2008) as well.

2.4 Spatial Hedonic Models

Hedonic pricing model often possess possibility of the impact of potentially omitted variables. It is impossible to measure all of the local characteristics that determine the housing prices. In this circumstance, houses near each other are likely to share similar unobservable attributes, which results in spatial dependence. Presence of spatial dependence causes biased and inefficient estimates for explaining variance in the dependent variables in traditional OLS hedonic models. The most common spatial econometric models to deal with spatial autocorrelation are the spatial lag model, also known as the spatial autoregressive (SAR) model, and the spatial error model (SEM). Spatial lag model (SAR) contains endogenous interaction effects, and spatial error model (SEM) contains interaction effects among the error terms (Anselin, 1988; Elhorst, 2014).

Anselin, Bera, Florax, and Yoon (1996) developed the testing procedure, robust Lagrange Multiplier tests, for a spatial lag or a spatial error model. In recent years, researchers took more interest in models containing both endogenous interaction effects and interaction effects among the error terms. The model that includes both effects is termed as SAC, SARAR or Cliff-Ord type spatial model (LeSage & Pace, 2010). Following these endeavors, LeSage and Pace (2010) introduced the spatial Durbin model (SDM) that include both endogenous and exogenous interaction effects.

In this study, as the results of Moran's I, and LM and LR tests of the spatial lag model and the spatial error model, SAC models are employed along with log-linear models (Anselin et al., 1996; Elhorst, 2014). Both an autoregressive in the lag-dependent and in the error structure are considered in the SAC model, spatial-autoregressive model with spatial autoregressive residuals, (Kelejian & Prucha, 1998),

$$P\_h= \rho WP\_h + X\beta + \mu\_h \text{ and } \mu\_h= \lambda W\mu\_h + \varepsilon\_h$$

where the house sales price P_h is a function of structural, neighborhood, and locational characteristics (X). The matrix W of spatial weights is calculated as a distance-based matrix between the houses (Anselin, 2002). The coefficients β represent the implicit price of each characteristic accounting for relationships with the neighbors. The error term μ_h accounts for spatial dependence in error terms. When ρ reveals to be 0, the model becomes spatial error model and when λ=0, it becomes spatial lag (autoregressive) model. If both parameters are zero the regression is based on ordinary least squares (LeSage & Pace, 2010).

One of the assumptions in creating spatial matrix and spatial model is that the process only allows unique xy coordinates for entire dataset. This means multiple sales for the same property cannot be incorporated in the model. As a result, only the most recent sale is used for the spatial models.

Testing and incorporating above techniques in Hedonic pricing models, the researcher provides both standardized and unstandardized coefficients, student t-values and their significance. In addition, plots of the frequency of standardized residuals will be studied for normality, and standardized residuals against standardized predicted values will be examined for homoscedasticity.

2.5 Environmental Amenities and Housing Valuation: Valuing Open Space with Hedonic Price Models

Hedonic price models have been utilized in numerous studies attempting to measure impacts of open spaces on property prices. The open spaces investigated include parks, nature preserves, forest, wetlands, and agricultural lands. Studies regarding parks and nature preserves will be reviewed in this section focusing on measurement, functional form and the monetary effect of amenities on property value.

2.5.1 General Open Space and Parks

More et al. (1988) were among the first to explicitly use a hedonic price model to measure the value of open spaces. The study examined the association between four parks and the values of single family houses in Worcester, Massachusetts. The authors used sales prices of houses sold within a 4,000 foot radius of each park to estimate impact of those parks on the value of properties. For the independent variable, a straight line distance to park and the street network distance to park was measured along with structural characteristics such as lot size, number of rooms, garage, and property age and condition. Four functional forms, linear, semi-log, log-log, and quadratic, were applied.

The study showed that all four parks had positive impact on values of surrounding properties, even though the amount varied significantly. On average, they found a $2,675 premium for a house located 20 feet of a park compared to a similar property located 2,000 feet away, beyond which the effect was negligible. While properties near 76 acre Elm-Beaverbrook park only received $64 premium, however, properties near 15 acre Greenwood park benefited a premium of $5,000. The authors explained the large gap in terms of the condition of the parks. Elm-Beaverbrook, a recreational park in the city center, suffers from vandalism and congestion with more than 60,000 visits a year. On the other hand, Greenwood is natural open space with the number of visits less than half of Elm-Beaverbrook's. It is quiet natural parks that add more value to nearby properties than recreational facilities dominated parks.

Bolitzer and Netusil (2000) examined the influence of public parks, private parks, golf courses and cemeteries on property values using sales data of 16,402 single-family houses in urban area of Portland, Oregon. The authors used distance to/from amenities as the key variables in explaining the impact of each of amenities. The two types of distance variables were employed; one as a dummy variable indicating whether the property is within 1,500ft radius of amenities or not; and the other is represented by six distance zones in 1,500ft range. Euclidean distance was applied and two types of functional form, linear, and semi-log, was used to specify the model.

In both linear and semi-log models, open space as a whole positively influenced the property values of houses within 1,500ft. An average sales price increase of $2,105 in linear and 1.43% in semi-log was accounted for the existence of open spaces within 1,500ft of a house. Also, increase in size of open spaces resulted in increase in housing value by $28.33 for each additional acre. Linear model showed A 20 acre open space presented with $2,670 premium on nearby property in the linear model, and $1,247 premium in the semi-log model. Among all the open space types studied, golf course had the greatest impact on housing prices with a premium of $3,400 in the linear and $3,940 in the semi-log form, followed by public park of $2,262 and $845 in the linear and the semi-log model respectively.

By examining distance zones, it was expected to identify increasing or decreasing impacts regarding proximity to amenities and positive and negative externalities. As shown in Table 1, the impact generally diminishes as the amenity gets further away. The most significant impact was between 401ft and 700ft of the linear model and 101ft to 400ft in the semi-log model, $3,576 and $2,755 respectively. In both models, impacts were not significant for the distances between 0 and 100 ft and for the semi-log model, impact of distances further than 1300ft was not significant. However, this result may be convoluted for the fact that all the open space types were aggregated.

Table 1 Impact of open space proximity

Distance variable (feet)	Impact of open space proximity (1990 dollars)	
	Linear	Semi-log
0 – 100	5,023.38	3,522.80
101 - 400	1,705.10**	2,755.36*
401 - 700	3,575.91*	1,982.80*
701 – 1,000	3,189.06*	1,522.09*
1,001 – 1,300	2,546.86*	1,454.59*
1,301 – 1,500	2,108.75**	1,004.16

* indicates P≤0.01, and ** P≤0.05 source: Bolitzer and Netusil (2000)

With the same data used in Bolitzer and Netusil (2000) studies, Lutzenhiser and Netusil (2001) examined impacts of open spaces on property values in different types of open spaces. This time open spaces were classified as urban park, natural area park, specialty park, golf course, or cemetery in Portland, Oregon. The authors used the acreage of each amenity in addition to Euclidian distance to/from amenities as the key variables in explaining the impact of each of amenities. Quadratic Box-Cox transformation on the size of open space was used to identify the most efficient sizes of each amenity in urban areas of Portland.

The study revealed that properties within 1,500ft of natural area parks received largest impact of $10,648 followed by ones near to golf courses, specialty parks, and urban parks. Cemeteries had no significant impact. Optimum sizes of each amenity and their premiums are shown in Table 2. Natural area parks required the most space and the specialty parks the least. Despite the least space requirement, the specialty parks had the largest premium of $27,500.

Table 2 Impact on property value and optimum open space size

Open Space	Impact on sales price of properties within 1,500ft. ($)	Optimum size and associated premium	
		Size (acre)	Premium ($)
Urban park	1,214*	148	11,500
Natural area park	10,648*	258	15,000
Specialty park	5,657*	112	27,500
Golf course	8,849*	169	9,000
Cemetery	-	-	-

* indicates P≤0.01 source: Lutzenhiser and Netusil (2001)

In attempt to measure increasing or decreasing impacts regarding proximity to each amenity, the authors had divided 1,500 ft. range into 7 distance zones. The most significant impact was distances within 600ft for all the amenities. Like the previous study, the impact generally diminishes as the amenity gets further away. Natural area and specialty parks had significant impacts at all distances. Natural areas not only had the largest dollar impact but also carried relatively constant, less diminishing, impact throughout the zones. Another noticeable result is the impact of golf course when properties are located within 200ft. The impact, the largest of all the results including all the amenities, is substantially greater than the ones for other distance zones. It may be inferred that the value of properties near golf courses critically depends on whether the property is adjacent to the golf course or not. Even though, this study developed more detailed distance zones for each amenity, it is still not clear on how the distance is related to value of properties. More specific research design incorporating continuous distance variables, view related variables, and size and usage related variables would provide more detailed results on how amenities affect the value of properties.

Nicholls and Crompton (2005) studied the effect of greenways on surrounding residential property values in three neighborhoods in Austin, Texas. In this case, the authors used GIS to calculate street network distances to the entrance of greenbelt to be more realistic. View and adjacency to the greenway was also included as a dummy variable. Since the authors carefully chose neighborhoods with distinct and homogenous characteristics, neighborhoods attributes were not controlled. For the meaningful and practical interpretation of the results, linear functional form was applied in this study.

In the study, the authors found that greenways generally have significant positive impacts on sales prices of proximate properties although large portion of locational variables failed to reach statistical significance. The authors impute the insignificance of the result to poor condition of greenways in Lost Creek and random accessibility to greenways other than the entrances. In Lost Creek, the greenway was abandoned as in natural state which may be considered as a disamenity. Also, properties away from the greenway had better view of the river and the city since the neighborhood is located on a hill. For these reasons, the impact of view of greenway was not significant in two neighborhoods and not applicable in the other. However, in two of three neighborhoods, adjacency to a greenbelt had significant impact on the property value. In Barton Creek, properties adjacent to greenway held a premium of $44,332 compared to similar properties in the neighborhood, while in Travis, a premium of $14,777 for the properties on the greenway. The authors used street network distance to greenway in an attempt to measure physical access to the greenbelt. Though the impacts were all positive in all neighborhoods, it was only one neighborhood that had significant impact. In Lost Creek, a foot decrease in physical distance to greenway was associated with $3.97 increase in a property value.

This research was specified with more detailed measures of locational variables. It also gave special attention to assumptions of hedonic models such as spatial autocorrelation and collinearity by segmenting markets and testing such issues with statistical methods like correlation, VIF, and tolerance.

Anderson and West (2006) examined the effects of proximity to open space on sales price using 1997 data from the Minneapolis–St. Paul area. The authors used Euclidean distance and size variables and their interaction terms for various types of open space. The open spaces include neighborhood parks, special parks including natural areas, golf courses, cemeteries, lakes, and rivers. In attempt to deal with spatial autocorrelation errors, the authors specify separate hedonic price models for the city and the suburbs with the incorporation of neighborhood fixed effects. Considering sales price and key dependent variables, such as square footage and distance, the authors used log-log functional form to specify the model. Box-Cox transformation

The results showed that decrease in the distance increases the value of property for every amenity measured except for cemetery. The largest impact was provided by the lake variable, 3.42% increase for every one percent decrease in the distance to the nearest lake. Neighborhood parks had relatively smaller impact, 0.35% increase of sales price increase for every one percent decrease in the distance to the nearest neighborhood park. Cemetery had insignificant impact. These results are similar to results presented in the above studies by Bolitzer and Netusil (2000) and Lutzenhiser and Netusil (2001). The coefficients associated with the interaction terms were confusing in that they were small and in mixed directions. Even though they were included to help explain how open spaces affect values in terms of their distances and sizes, they were not significant. This may be the result of some omitted characteristics associated with open spaces, such as increased noise or traffic flow.

The results from neighborhood characteristics indicate that density, high-income, higher population under age of 18, and close distance to CBD had positive impact on the value of properties. This inclusion of neighborhood fixed effects may control for unobserved housing market variables. It minimizes spatial autocorrelation errors caused by omitted variables.

Donovan and Butry (2011) estimated the effect of urban trees on the rental price of single family homes in Portland, Oregon. The authors measured number of and crown area of trees in the lot and public right of way to use as independent variables. Street trees directly fronting a house's lot were counted for each property. Also, Euclidian distance to park was added as an explanatory variable. Semi-log form was applied for the hedonic model. The results suggest that number of trees either in the lot or the street positively impact the rental price of the properties. One percent increase in number of trees in the lot was associated with 0.441% increase in rental prices, which is $5.62 in monthly rent. Also, one percent increase in number of trees in the fronting street was associated with 1.64% increase in rental prices, which is $21.00 in monthly rent. However, crown area of both the lot and street did not have significant impact. As shown by numerous previous studies, distance to park had a significant positive impact on rental price. The rental price of a property was increased by $4.15 as the property is located 100m closer to a nearest park.

2.5.2 Nature Preserves and Forests

Garrod and Willis (1992) examined the benefits of woodland, river, other suburban settlements, and wetland, as they named countryside characteristics, on rural areas of Gloucestershire, England. Their focus variables were concerned with woodland coverage of more than 20 percent of the land surrounding the property in a square kilometer, view of woodland or urban area, and the presence of a river or wetland within a kilometer of the property as a dummy variable. They also included average height above sea level, and presence of industrial facilities and pub within one kilometer radius as their explanatory variables. Semi-log functional form and Euclidian distance for measuring approximation were applied.

The study presented that house prices are higher by 7.1% when more than 20 percent of the land surrounding the house is surrounded by woodland in one square kilometer. Presence of river and other suburban settlements within one kilometer radius is associated with 4.9% and 8.34% increase of sales price, respectively. Interestingly, coefficients of presence of wetland and view of woodland presented negative impacts. The negative impact of wetland, 18% decrease in sales price, was due to hazardous condition of wetlands, which rather viewed as disamenity according to the authors. However, the negative impact of having a woodland view on house prices was not explained.

Tyrväinen (1997) used apartment sales data to analyze how distance to the nearest forest park, forested recreation area and watercourse, and the percentage of forested land in the housing district affect sales prices in Joensuu in North Carelia, Finland. Sales price data was modified as sales price per square meter, since the subject was apartment sales where size varies and is the dominant characteristic of price. The authors used street network distance for recreation area of which the main purpose is to visit and enjoy. On the other hand, distance to forested area was measured by Euclidian distance. Both linear and semi-log functional form were applied and interpreted in the study.

As is expected, being closer to forested recreation area had a significant positive effect on the sales price. One hundred meter decrease in distance from a recreation park to a property is associated with 41.78 FIM, as estimated in the linear model, and 0.16%, as in the semi-log model, increase in sales price per square meter. Likewise, as the percentage of forested area in the housing district increases, the value of property increases. In addition, both models presented a significant positive impact for watercourses. However, the result showed being closer to a forest park negatively affected house price. The authors partially explained the reason with the condition of the forest park. Unlike the forested recreation areas, which are well maintained with trails and paths for jogging and skiing, the forest parks are often times small strips of land left in nature without maintenance. Similar to findings from other researchers, poorly managed parks and urban nature areas do not always impact positively on value of residential areas.

In an extension to this study, Tyrväinen and Miettinen (2000) conducted another study that excluded insignificant variables and included view of a forest as an independent variable in a different city, Salo, Finland. In the latter study, the authors confirmed that decrease in distance to a forest preserve increases the price of houses significantly. The result showed that one kilometer decrease in the distance to the nearest forested area from a property is associated with an average 5.9 percent increase in the sales price of the property. Also properties with forest view had on average 4.9 percent higher prices than ones without it, others being equal.

Thorsnes (2002) examined the effect of nature preserve on building lot prices in three subdivisions in Grand Rapids, Michigan. The author used sales data collected by

Tax Assessor's Office over 30 years. The explanatory variables mainly consisted of dummy variables indicating whether the lot is bordering with nature preserve, park, large lot, or subdivision. It also included subdivision characteristics such as whether the lot is on a cul-de-sac or corner. Neighborhood characteristics, on the other hand, were not included due to well-defined boundary of each market. The results were estimated in separate models for each subdivision in both linear and semi-log functional forms.

The results show significant amount of premium on the building lots bordering the preserves in all three subdivisions. In Forest Park, adjacency to nature preserve led to $8442 premium in linear model and 31.10% higher price in semi-log model, on average, compared to other lots in the subdivision, holding other factors constant. Similarly, lots bordering the preserve on River Woods benefited $5822 and 18.56% premium on their sales price, and the lots on River Highlands acquired $7207 and 35.01% higher selling prices. In addition, lots adjacent to parks received premium ranging $1683 to $1178 where the variable was applicable, i.e. no park surrounds River Woods. In semi-log model, the coefficients for park adjacency were around 6.8% in both subdivisions. However, large vacant lots behind the properties had mixed impacts on the price of properties. The variable had positive impacts of $2442 (9.16%) and $524(2.70%) on the value of the properties in two of the subdivisions, whereas lots in the other subdivision were faced with negative impact of -$96 (-5.98%) for having a large lot behind their properties. The author explained the inconsistency in regard to existence of nature preserves near the properties. Open space that already exists in the nature preserve is considered as substitution for larger lots to some extent. One noticeable result is that lots adjacent to a creek with low, forested area had greater premium than lots adjacent the preserve in the subdivision that had creek running through the area. This result suggests that buyers appreciate properties with both forest and water features.

This study is significant in the fact that it controlled for market segmentation and site selection to clarify interpretation. The author also used sales data of building lot instead of price of houses, which automatically controls for potential structural characteristics of the houses. This explains such high R^2 values ranging from 0.76 to 0.914 among the models. For the reasons stated, the specification of research that the author designed provides sense of reliability to the result of the study.

Mansfield et al. (2005) assessed the relative value of different types of forest cover to homeowners in the Research Triangle region of North Carolina. In order to introduce new measures of urban forest, the authors explored various definitions of forest cover and greenness. In addition, they created two different variable types for distances to amenities, one measuring adjacency and the other measuring Euclidian distance to a nearest forest. The forest in the area was categorized into institutional and private forest to capture different services offered by forest cover. In attempt to examine the interactions between varieties of forest variables, interaction terms were introduced to the model. In addition, greenness variable was defined as 30-m square pixels with the Normalized Difference Vegetation Index (NDVI), which allows measures at the property level. The functional form used was linear.

The study confirms that generally greenness and forest have positive impacts on value of properties in the area. A positive coefficient for proportion of forest cover suggests that parcels with a greater proportion of forest cover have greater value, controlling other factors. Also, one meter increase in distance to institutional and private forest is associated with decrease of the sales price by $4.22 and $27.74, respectively. In addition, an average price of a property adjacent to private forest is $8347.25 higher than price of the ones located further than 20-m away from the private forest. Adjacency to institutional forest, however, had no significant impact. Another unexpected result was negative impact of mean greenness to price value of a property. It is because the value of the mean greenness has strong negative association with the size of a house. The value of the mean greenness variable declines as the proportion of the house size increases in the parcel, other factors being equal. Proportion of a house in a parcel is often related to housing type and location, which strongly influences the price.

S.-H. Cho et al. (2008) examined how the spatial variation in amenity for both quantity and quality of green open space influences the housing market in City of Knoxville and Town of Farragut in Knox County, Tennessee. Variables regarding forest patch were measured in relation to size, proximity, spatial configuration, and species composition of open space. The size and proximity were used to determine mean forest patch size, patch density and distance to a patch whereas the spatial configuration and species composition were processed to measure forest edge density and determine different types of forest patches, evergreen, deciduous, and mixed. The forest patches were categorized based on percentage of green foliage and shed foliage in response to seasonal change. Patch density, the degree of spatial heterogeneity in the forest open space captures the visual and scenic diversity. Previous studies have shown that amenity value for open space increases with a positive value of high patch density. Edge density, perimeter-to-area ratio, measures the scenic diversity and the complexity of open space boundaries. An edge density with positive, high value implies more rough edges and natural patches whereas an edge density with negative, high value suggests smoother and synthetic open space boundaries (Jacqueline Geoghegan et al., 1997; Palmer, 2004). Other noticeable variables in the model are average prime interest rate less average, inflation rate, season of sale, vacancy rate, and unemployment rate. The authors included those variables in an attempt to control for external economic factors that might influence the housing market.

As theories and previous studies suggest, the result indicates consumers' general preference to green features in the housing market. On average, a property 100 m closer to an evergreen forest patch has a price $692 higher than the other houses, others being equal. Similarly, locating 100m closer to a deciduous forest patch increases the average house price by $589. The fact that forest patch density and forest edge density resulted in mixed, negative and positive respectively, coefficients is not surprising since those measures represent preference on types of open spaces, not general preference whether consumers like green or not. Likewise, the mean patch size has a negative influence on housing price, which indicates, on average, the consumers prefer smaller forest patches in the study area.

The study estimated two different models to capture differences in preference between residents in Rural–Urban Interfaces and ones in Urban Core areas. In the rural-urban area, proximities to evergreen forest had positive impact on sales prices. However, in the urban core area, it was deciduous forest and mixed forest that had positive coefficients. Interestingly, these findings imply that consumers value evergreen trees more in the area of green abundance, and deciduous and mixed forests more in the area of scarce green open spaces. This suggests that a forest is valued differently according to its type and location. Similarly, the values for patch density and patch edge differ based on the type of urban setting. For patch density, it was positive for rural-urban area and negative for urban-core area, which means that larger open space is preferred in urban area and diverse and fragmented pattern is more valued in rural-urban interfaces. Lastly, the edge density had contradicting results as well. The impact was positive for rural-urban area, and negative for urban core area. This concurs with common expectation people would have in rural and urban settings. In rural-urban setting, rougher and more natural-looking forest patch boundaries are expected and thus valued more. On the other hand, in urban settings, smoothly trimmed and man-made boundaries for open spaces will be expected and preferred. To summaries, in rural-urban areas, open space with evergreen trees, diverse and fragmented landscapes, and natural-looking edges impacts positively on housing market. In urban core areas, on the other hand, larger open spaces with deciduous and mixed trees, and smoothly trimmed and man-made boundaries are preferred and thus highly valued.

Neumann et al. (2009) examined the association between residential property values and proximity to various types of open spaces including agricultural land, cemetery, conservation land, golf course, recreation park, and a National Wildlife Refuge (NWR) in central Middlesex County, Massachusetts. The focus of the study was on NWR and comparing the association of proximity to five other open space types. The amenity measures used to create independent variables were Euclidian distance to the nearest open space of each type and diversity index of open space types within neighborhoods. The authors applied a semi-log functional form to the model and accounted for inflation when presenting results in dollars.

The result indicates that three distance variables, golf course, recreation park, and national wildlife refuge, are significant out of the six open space types. Agricultural land, cemetery, and conservation land had statistically insignificant impact. The model reveals that one meter closer to a golf course increases the price of a property by $4.94, other factors being equal. Similarly, moving one meter closer to recreation park is associated with $12.03 increase in the property value. The Great Meadows National Wildlife Refuge also had positive impact of $6.23 for one meter proximity to a property. The authors presented the dollar values converted into 2007 values accounting for inflation. Thus, when the impact of NWR was presented, it was a price premium of $984 for being 100 meters closer instead of $623, value in 1998.

The coefficients on the diversity index were negative as the previous studies revealed. In urban settings, residents prefer less diversified land uses and homogeneous landscape features in the neighborhood. Large open spaces with relatively simple man-made boundaries, which have low value of diversity index, are more highly valued than diversified, natural looking open spaces (G. Acharya & L.L. Bennett, 2001; Neumann et al., 2009). In this study, the large diversity index, index of open space diversity within 1000 meters, is significant with a negative coefficient. This confirms that residents in central Middlesex County, Massachusetts monetarily more value large, homogeneous open space than numerous small, diverse open spaces. The authors, however, pointed that the pure size of the refuge, which dominated the index, might have complicated interpretation of the diversity variable.

2.6 Environmental Disamenities and Housing Valuation: Valuing Proximity Effect of Industries on Residential Value with Hedonic Price Models

Compared to a vast number of amenity related hedonic studies, studies analyzing proximity effect of industries on residential value has been minimal. In this section of the review, empirical literature regarding oil industry, electric transmission lines, and general industrial sites are reviewed.

Flower and Ragas (1994) examined negative impact of oil refinery on property value in St. Bernard Parish, LA. Two refineries, run by Mobil and Murphy, were located near each other in the study area where a homogenous community was formed surrounding the industry. The authors did not include neighborhood characteristics but included other common structural characteristics and distance variables. The area was divided by 10 zones in regard to their distance to each refinery, of which one zone was designated as a confluence zone. The confluence zone was located in between the two refineries. The focus of this study was to identify changes in the effect of the two refineries on property values over time on the east bank of the Mississippi River. The study identifies two environmental events that could have caused a shift in residents' perceptions of surrounding environment. During 1982, a nickname "Cancer Alley" was given and publicized for the Mississippi River from Baton Rouge to the river delta following published studies relating a statistical link between industrial pollution and the high incidence of cancer in South Louisiana. In the following year, 1983, a storage tank at the Mobil Refinery exploded. Assuming that those incidents negatively affected residents' perception toward refineries, the authors attempted to capture the changes in effect by looking at the market in three different time periods. A negative influence was expected in all years and some more discounts to be paid after a change in environmental awareness.

The result reveals that the discounts, in this case negative direction, increased after 1983, the time of incidents, in many of the zones but some zones reacted unexpectedly. The discount was up to $6620 and the confluent zone suffered from increasing discount over time as expected. However, housing markets of some zones were not affected by these incidents and the impact diminished over time. The authors explained for some of those unexpected for the buffer zones separating the industry area of the refineries. Neighborhoods located near the Mobil refinery were provided with much wider and plant rich buffer zones that worked more efficiently. In addition, the zone fronting the Mobil refinery consists of traditionally prestigious and desirable neighborhoods, of which considerable portions are luxurious smaller homes. According to local appraisers, these types of neighborhoods helped minimize the influence of down cycles in the market. They also had potentially two positive externalities impacting the zone in northwest of the Murphy refinery. First, the best private elementary school in the area was located in the zone located at northwest of the study area. The proximity value of the school was not accounted for in the study. Second, around the time of the incidents, when the residents' perception may have changed, couple of prestigious new developments had taken place near the study area. These developments had occupied the only available vacant land within the physical boundary of the site, bordered by the river on the South and swamp on the North.

In a similar attempt, Boxall et al. (2005) focused on oil and gas production facilities, mainly wells, near rural residential area in Central Alberta, Canada. The study estimated the impact of proximity to oil wells on property values using variables that count number of each type of wells within 4km radius. Interestingly, monthly average residential property prices in Calgary, adjacent to study area, was included as an explanatory variable to account for housing market condition. For other locational variables, view of Rocky Mountains and counties the properties reside on were entered as dummy variables. The authors hypothesized that visual impacts, noise, traffic, odor and perceived health hazards of oil facilities would decrease residential prices of approximate properties. The results were presented as price effect from 0 to the first unit of the variable, from 0 to the mean level of the variable, and marginal effect at the mean level of the variable due to the difficulty in interpreting coefficients of log-log function form models.

The results consist of negative coefficients for all the oil facility related variables, of which many are significant. Of the significant coefficients, the number of sour gas wells and flaring oil batteries within 4 km of the property has larger negative impact. When the first flaring oil battery is introduced within 4 km, price of a property decreases by $10703. Similarly, price effect from 0 to the first unit of the sour oil well is minus $6206. However, the effect decreases as the number of wells increases. For example, when there are 3 or 4 wells within the distance, an additional well is associated with approximately $2000 decrease in the property value. Thus, whether the property has a well or not is more critical than the number of wells. The impact of sweet well was insignificant. The effect of both sour and sweet wells combined, however, was negative and significant. The total number of wells had a first-unit effect of $8148 and a mean effect of $20,942, which represents the price effect from 0 to the mean level of the variable. This means, on average, the wells in the area discounted approximately 7% of average property value.

S. W. Hamilton and Schwann (1995) assessed the effect of high voltage electric transmission lines on the prices of single detached houses in Metropolitan Vancouver area. During the process, the distance to the center of the transmission line right of way, adjacency to the right-of-way, and number of towers/lines visible were recorded and used as independent variables to account for negative impacts of such facilities on nearby residences. The result revealed the native association of the electric transmission lines to property value, which was, however, limited to a narrow band. The negative impact was found to be largely due to the visual externalities of the transmission towers.

The model estimated that visibility of the towers decreased the value near properties by $6,669, which was 5.7 percent of the average price of the properties adjacent to the towers. The mid-range properties, between 100m and 200m from the lines, had negative impact of $907 on average from the view of the towers. Proximity to the transmission lines had negative impacts for all properties within 200m. As expected, properties adjacent to the lines benefit greater premium than mid-range properties, by $6,740 and $3,438 respectively, when the distance to the lines increases by 30m. When an adjacent property is relocated 30m further away from the power line and loses the view of the towers, the price increases by $7,339, which is 6.3% of the average property value. However, the negative impact decreases as the properties get further away.

2.7 GIS

2.7.1 GIS Techniques in Valuation Process

A GIS is a collection of hardware, software, data, policies, procedures, and people for the input, storage and retrieval, manipulation and analysis, output and modeling of spatially referenced data. The information stored in a GIS can be expressed visually and analyzed spatially and statistically. Basic analysis of GIS is measurement of lengths, distances, areas, and perimeters. Higher level of analysis involves measurement of landscape patterns and examination of relationships between different geographic features. GIS can be integrated into many other information system frameworks.

Growing number of researchers are incorporating GIS capabilities in hedonic analyses of property values. Compared to previous manual methods, GIS excels in the process of data collection. During the process, the data collection method remains flexible with GIS while the manual method should remain unchanged throughout the process. Unlike the manual method, with which the variable must be decided before the collection process, data collected by GIS approach can be modified after its collection (Powe, Garraod, Brunsdon, & Willis, 1997). Most of all, governments, agencies, companies, and institutions have been constructing vast amount of GIS database around the globe taking advantage of recent technological advance in digital technology.

In addition to its data availability, GIS holds clear advantages in integrating large databases like census data, services and facilities, aerial photographs, and remote-sensing data into a GIS and deriving spatial variables from the data collected and formatted (TheĻriault & Des Rosiers, 2004). With GIS applications, researchers can utilize data to develop variables more efficiently than the manual method. The speed and accuracy of GIS application enables researchers to develop a greater variety of spatial variables in a limited time (Powe et al., 1997). More specifically, many of the functions available within GIS applications facilitate in deriving structural, neighborhood, and locational variables that capture the variation of property attributes. The contributions of GIS to the property price analyses are: (i) visualization; (ii) improvement in methods of measuring variables in the hedonic model; and, (iii) use of GIS in combination with spatial statistics techniques as integral tools in the hedonic analysis. This could take spatial factors into account to prevent autocorrelation which may otherwise bias hedonic results (Nicholls, 2002).

2.7.2 GIS in Early Stage of Application in Property Industry

At the start of the GIS analysis in the property industry, researchers utilized the visualization capability of GIS into site selection and location analysis. Barnett and Ason Okoruwa (1993)identified the optimum location for development of a suburban residential community in Durham County, North Carolina in regards to six sets of criteria, (i) traffic activity; (ii) zoning restrictions; (iii) slope of terrain; (iv) existence of water features; (v) lack of railroad noise; and (vi) proximity to major employment, retail, and recreation areas. Maps pertinent to each of these factors were overlaid to find the suitable setting. In effort to integrating spatial and statistical information, Bible (1995) integrated demographic and socio-economic data with spatial data. Multiple listing service (MLS) data, typically summarized in tabular format, was spatially integrated by individual street addresses or at the aggregated level of MLS zone. Integrated information included value and volume of sales; average number of days on the market; ratio of sales to list price; and, average price. In similar effort, Fung, Kung, and Barber (1995) applied GIS to map current and past real estate values in order to identify market trends. These researches provided new insights into local property markets.

Simons and Salling (1995) used GIS to facilitate the integration of graphic, textual, and statistical information. The authors overlaid maps of land parcels, land use, and street networks and associated data of ownership, tax assessment, and environmental factors such as locations of commercial and industrial activity to identify the least expensive parcels for redevelopment. The result presented recommendations of clusters of parcels most cost-effective to redevelop to aid decision making process.

2.7.3 GIS Techniques in Hedonic Price Modeling Literatures

Hedonic analyses with regard to its spatial configuration have been conducted by a number of researchers in numerous research designs incorporating landscape, land-use diversity, open space, view, and etc. Improvement on GIS software capability and expansion of GIS data establishment in both quantity and quality has enabled researchers to develop more complex research designs of open space valuation process. GIS is used to process data and provide variables associated with spatial landscape indices, distance between amenities/dis-amenities and properties, view of open space, land cover, land use diversity, etc. Those spatial variables can be categorized into three major areas of interest, access, view, and area and pattern.

2.7.3.1 Access

There are several ways researchers have measured accessibility to include as a spatial variable in hedonic price model. Estimating the impact of accessibility or proximity to amenities from subject properties is the major concern for researchers attempting to find out the marginal benefits associated with the location of properties. The most common measure of accessibility is a straight line distance. In addition to the conventional distance variable, researchers have included car travel time, walking distances, access indexes, and several others in the process. In the procedure, GIS holds the most critical role in collecting and formatting the data and processing it to be included as variables.

Distance

The simplest way of measuring distances between properties and dis/amenities is to draw a straight line between the two points, Euclidean distance. Euclidean distance is used in most of the amenity valuation studies using hedonic price models. Especially, in earlier studies of 90s, the distance was usually the only measure for accessibility variables. Jacqueline Geoghegan et al. (1997) focused on locational factors like distance to the natural amenities, the central business district, and the nearest major road, measured by GIS. Many other studies also applied the straight line as their distance variables (Lake, Lovett, Bateman, & Day, 2000; Mahan, Polasky, & Adams, 2000; TheĻriault & Des Rosiers, 2004). The Euclidean distance was also used for calculating proximity to disamenities like power lines and freeways as a parameter representing visual and noise externalities (TheĻriault & Des Rosiers, 2004).

In addition to a straight line approach, several researchers applied walking distances and car time distances from each property to amenities as measures of accessibility (Lake et al., 2000; Poudyal, Hodges, Tonn, & Cho, 2009). TheĻriault and Des Rosiers (2004) used TransCAD GIS to compute car-time distance to the main activity centers by simulating the route based on the road network with various impedance constraints and turn penalties. In a different approach, Kong, Yin, and Nakagoshi (2007) generated a land-use map of the area from remote sensing data, which comprises of 2004 Spot Images (10 m, 4 bands) to develop a digitized road network data. A vector topographic map (1:10 000) was created as a reference to generate the road network and walking network. Road network was categorized as arterial road, secondary truck road, branch road, and path; and walking network was categorized as river/water, mountains, and others. The land-use map was converted into grid data of 10m resolution in order to assign different impedance values to the grid cells according to travel types and road conditions. To calculate the travel time from each property to the nearest amenities, the authors used the distance/cost weighted sampling tool in the GIS spatial analysis module with the travel speed, determined based on the above condition. In a similar approach, S. E. Hamilton and Morgan (2010) investigated the routes between the beach and the residential properties accounting for obstructions and limited access on private properties. To make the route more accurate, the authors verified the condition of roads and accessibilities with local county. The study revealed that the actual access distance differed from the linear distance to the beach due to limited access areas in many cases. Some properties with shorter linear distances to the beach had longer route distances than some other properties that were located further away.

It is critical to use a variable that better explains the original intention of the research design concept. To date, researchers have measured accessibility or proximity in three different ways, Euclidean distance, walking distance, and car time distance. Each measure serves different uses and purposes. Walking or driving distance may be more appropriate for amenities where residents visit and enjoy like recreational parks. On the other hand, a straight line distance would be more appropriate for amenities that residents enjoy the view and environmental benefits of open spaces passively (Poudyal et al., 2009).

Access index

Powe et al. (1997) focused on a different measure of accessibility to an amenity, woodland in the New Forest of England. Residential accessibility to woodland was determined by a woodland access index calculated with distance to and area of forests using a GIS.

$$\text{forest access index} = \sum_{i} \left(\frac{\text{area}_i}{\text{distance}_i^2}\right)$$

The index was calculated by the distance between a house and forest sites and the area of corresponding sites for each distances. By utilizing the index, positive association between the access and residential areas of woodland could be calculated. Like conventional spatial hedonic studies, the study also included variables explaining other environmental amenities and disamenities such as the distance to the sea front, location within 500m of the sea and 200m of a river, distance to business district, location within 500m of an oil refinery, etc. In similar attempt to examine the influence of wetland amenities, Mahan et al. (2000) utilized GIS to provide variables that specify and distinguish between multiple occurrences of amenities which might impact on sale prices of residential properties. The authors considered distance to, and size and shape of, the nearest wetland area in Portland, Oregon

2.7.3.2 View

Before GIS was commonly adopted, researchers determined the existence of a view by visual inspection. This process is exceedingly time consuming and subjective in determining categorization of views. From late 1990s, these hardships have been overcome through using GIS in visibility analysis.

Planimetric representations of the view

In an attempt to estimate the extent and visibility of surrounding physical features in a hedonic model of a residential housing market, researchers utilize GIS to build the topography of surrounding areas and examine the viewshed from each property. In the process, the GRID module of ArcInfo is used for planimetric simulation. During the process of planimetric simulation, the viewshed is measured in two steps; (1) measuring what can be seen from each property; (2) weighting each visible cell according to its distance from the observing point. To calculate visibility, DTM of the study area is created using the building structures, slopes and land elevations generated by triangulated irregular network, TIN. With the DTM created, a viewshed, view from a property's window, is calculated using an observer height and a viewing angle. The viewshed is then overlaid with land-use map to identify visible land-use from the property. The second step, weighting by distance, applies one of three distance decay functions to each visible cell; no distance weighting; an inverse linear distance weighting; and an inverse-squared distance weighting (Lake et al., 2000; Lake, Lovett, Bateman, & Langford, 1998; Palmer, 2004; Paterson & Boyle, 2002). In addition to the second step, obstruction of views by surrounding buildings and features may be included when calculating view shed (Lake et al., 2000). The planimetric simulation is successful in quantifying the dimensions of views including areal extent, depth, and relief (Germino, Reiners, Blasko, McLeod, and Bastian (2001).

Panoramic simulations

Panoramic simulation, on the other hand, is used for quantifying the composition of views including land cover, diversity, and edge of land cover. The surface-drape calculation in the ARCPLOT module of ArcInfo is conducted in the process of panoramic simulation. The resulting image from surface-drape simulation is converted into an ArcInfo Grid file which is then used to produce polygon coverage for quantitative spatial analysis. The polygon attribute values are coded with the initial lookup table values of each land cover class in the panoramic display (Germino et al., 2001).

The Shannon±Weiner index (H') (Shannon & Weaver, 1949), which measures the diversity of land cover for each panoramic view, is calculated as,

$$H' = (-3.3219)\sum(p_i)(\log_{10} p_i)$$

where p_i is the proportion of the total view for each land cover class (i). Greater index in composition indicates a less predictable sample composition.

CHAPTER III

THEORY AND HYPOTHESIS

3.1 Value of Environment

Value means more than price. It encompasses degree of general importance or desire for a thing, ethical decisions and future predictions associated with an individual's circumstances and much more. The value for an individual is established during childhood and becomes stable toward adulthood based on culture and surroundings (Morris, 1956). Morris (1956, pp. 9-11) suggested three kinds of value associated with objects. Operative values which reflect predispositions and tendencies in preferences for an object; conceived values which reflect foresight and are more symbolic in nature; and object values that is the actual preferred or desirable regardless of "…whether it in fact preferred or conceived as preferable." These three aspects of value are also important when we attempt to measure economic value of environment. Environmental valuation methods often approach the process on the basis of how people value their surroundings.

The importance of a natural ecosystem has been repeatedly emphasized by planners, decision makers, researchers, and even residents of places (Slocombe, 1993; Yli-Pelkonen & Kohl, 2005). It is not overstating to say that the existence of life depends on the service of natural ecosystem. Nonetheless, it is almost impossible to economically value the natural ecosystem in dollar terms due to its extreme complexity, dimensionality and comprehensiveness. Despite its difficulty and controversy, economists and environmentalists have attempted to value ecosystems and their services in order to set priorities in decision making processes.

One of the reasons economic valuation of ecosystem is challenging is that economics is more concerned with prices than with values or importance. Price of a good does not comprehensively reflect its importance, which also comprises social and philosophical aspects. Resources of great importance to humans might not be valued as high as it should be. Most jewelry is priced higher than water or even air, even though both are essential for life itself. But price is not determined by the importance of a good to life or the real value of a good. The price is determined by supply and demand. The abundance of resources often keeps prices too low; or even so low that no markets develop and thus no prices exist (Heal, 2000), but this does not mean these goods are without value. Nonetheless, environmental valuation attempts to estimate the economic value of non-market natural resources to reveal their fundamental importance at least partially. The difficulty in capturing economic value of resources comes from their non-rival and/or non-excludable characteristics, which is usually caused by inefficient and uncritical allocation in markets. Drinking water and fresh air is provided for everyone and one person’s use of the resource in a neighborhood does not diminish another person’s use, non-rival. Also, once the quality of such resources is improved, every member will enjoy the same level of quality, non-excludable (Loomis, 2000). Some resources are valued at high prices due to peoples’ need in market. However, the proportion of resources that are being valued in the market is extremely small compare to what the services the ecosystem provides. To capture the value of those services a variety of types of measures for ecosystem, especially for non-market valuation, have been developed (Costanza et al., 1997).

3.1.1 Non-market Economic Value of Environment

Non-market value in environment can be categorized into two general classifications, use and non-use value. More et al. (1996) classified both use and non-use values and explained the other values that are included in each classification. The explanations are as the follows.

Use values generally mean the benefits a resource produces for people when they use it. It is also referred as instrumental value. Instrumental value may be explained as the value that "clearly depends on the relation of the thing in question to the good (or supposed good) of something else" (Attfield, 1998). In this regard, instrumental value is closely related to markets, even though it is not a market value. For example, traditionally, use value of a forest is derived from timber or grazing. In market, these goods are traded, which means they are given a use value. However, as people started to recognize many other aspects of forest resources, other use values from wildlife, recreation, and natural beauty have been revealed as additional use values of a forest. The most common use value from a resource comes from its capability to provide recreation, aesthetic appreciation, and spiritual values. These use values are typically captured by travel-cost or hedonic models. These resources have economic value because people make sacrifices or show willingness to pay by actual transaction of some other goods in order to use them.

Non-use value, on the other hand, is more subtly even obscure concept. As it is revealed by its name, it is defined as the benefits received by people who do not use it. Non-use value includes existence value, altruism, bequest value and intrinsic value. Existence value reflects satisfaction from knowing that the resource exists. Altruism is the term used to define the value derived from having other contemporaries use a resource. Bequest value reflects willingness to pay to protect the resource for future generations (Loomis & Walsh, 1997). And, intrinsic value is the value of itself. It is from the belief that "natural objects have value as ends in themselves regardless of their relationship to man" (More et al., 1996). Rogers and Bardenhagen (2013) accept "…the idea that monetary measures of ecological resources under-represent the value associated with these resources. The methodology utilizes stakeholder input to assess the perceived intrinsic values of ecological resources associated with a particular place in multiple dimensions."

3.1.2 Intrinsic Value, Existence Value, and Non-Use Value

There is a complication on the definition and scope of existence value and intrinsic value among researchers (Aldred, 1994; Attfield, 1998; More et al., 1996; O'Neill, 1992). It needs due consideration of concepts and meanings to understand and apply them in environmental valuation.

Intrinsic value in environment needs to be defined more precisely due to its obscurity. It is stated earlier as it is value that depends solely on the intrinsic nature of the thing in question (Attfield, 1998). The definition that most closely relates the intrinsic value and human nature is termed by More et al. (1996) who refer to intrinsic value as the idea that "…objects including things, species, and individuals have an inherent worth that makes them valuable in and of themselves, regardless of any human benefit or cost they may generate." In this regard, intrinsic value is the value by itself and no human can relate or value its true inherent value. In this respect, Freeman Iii (2003) argued that the concept of intrinsic value does not provide basis for dealing with environmental management questions related to economic values and trade-offs that form essential background on providing measures of the economic values of environment and natural resource system.

Aldred (1994) defines existence value as "the value of an object in the natural world apart from any use of it by humans and all value which does not arise out of use of an environmental feature". He considers of existence value in a broad perspective that categorizes existence value as opposed to use value, which basically is non-use value. He suggests that the value associated with indirect use, vicarious use, bequest, aesthetic value, and intrinsic value are all components of existence value. However, this definition, like many others, draws a lot of controversy.

According to the definitions above researchers have termed, the hierarchy and scope of the two concept is still not clear. However, it is common understanding that existence value may include intrinsic value, but they are not equal (Aldred, 1994;

Attfield, 1998). According to Attfield (1998), existence value may also include instrumental value and partial intrinsic value. He argues that intrinsic value is not subset of existence value because object of mere existence, which still has existence value, may not have any intrinsic value. He believes only objects with positive quality or quality of life holds intrinsic value. In his account, a resource is regarded to have both intrinsic and existence value when the resource has diverse quality, one for its existence and one for its quality. However, this view is largely disputed by other theorists (More et al., 1996; O'Neill, 1992). Intrinsic value is the value a thing has “in itself,” or “for its own sake,” or “in its own right.” Whether an object has quality or not does not matter, and we cannot even determine the quality of an object for its own sake and right.

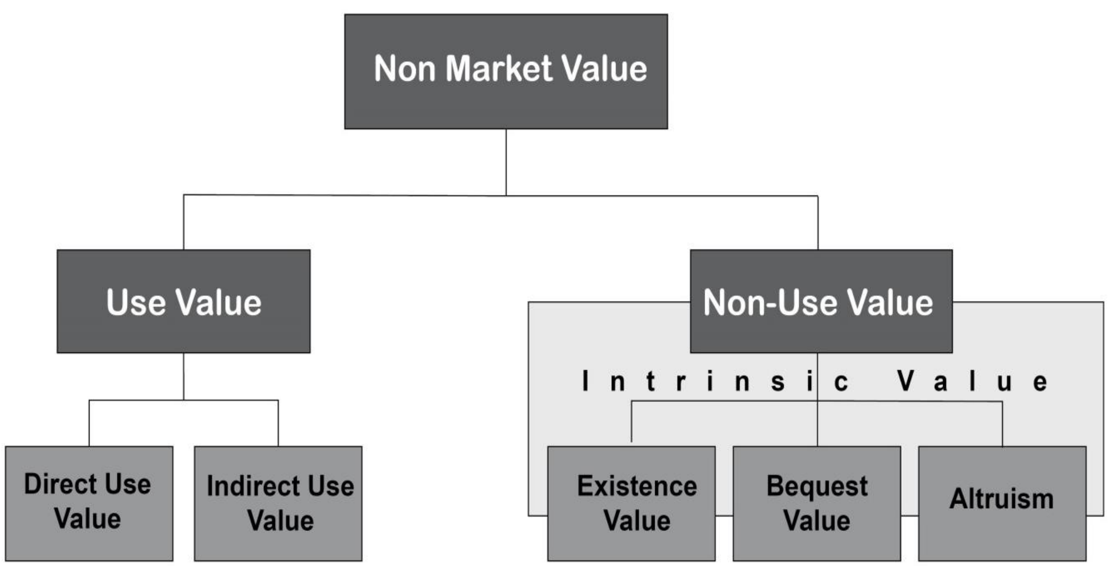


Figure 1 Classification of non-market value based on O'Neill (1992), Aldred (1994), More et al. (1996), Attfield (1998)

With this complication between existence and intrinsic value, the question now is what is being valued for each type of value. The component that is being valued in a natural amenity can be “the thing itself, knowledge of the thing, and the satisfaction that people derive from the thing” (More et al., 1996). Intrinsic value may be valued with mainly ‘the thing itself’ and partially ‘knowledge of the thing’. However, as stated earlier several times, the value for the thing itself is impossible to measure for the valuer being human. It is only partially valued by the knowledge of the thing which is anthropocentric. On the other hand, for existence value, one can attempt to measure the value of a natural amenity from satisfaction measure drawn from people and people’s knowledge of the thing that particular components of the subject amenity are important or valuable. This means that amenities can be valued by people for the acknowledgement of their importance even if they don’t use them. To summarize, one can examine non-market value of an amenity, either partially or relatively, by examining other use and non-use value of the amenity.

3.1.3 Hedonic Price Model and Recovery of Intrinsic (Non-Use) Value

Hedonic pricing models are useful for estimating the value of nonmarket environmental amenities and disamenities, such as parks, open space, air pollution, noise, and proximity to noxious facilities (McConnell & Walls, 2005). Despite the limitations, issues, and assumptions required, the method is a legitimate measure to value environmental resources, as F. Des Rosiers et al. (1996) note that hedonic models have been found to be the most reliable method of establishing the implicit value of non-market attributes associated with residential properties. Hedonic pricing models estimate the implicit prices of the characteristics of a composite good using its various attributes of the subject (Can, 1990, 1992; Freeman Iii, 2003; Rosen, 1974). The method derives monetary values from the characteristics that differentiate each product among other closely related products. The characteristics of a good that please consumers are examined using observed price data of related goods, which reveals consumers' preference.

Even if the hedonic modelling of the research produces statistically significant valuation of the amenity, there still are limitations in the research of examining non-market value of the amenity in a long-term period. The method is ill-equipped to capture the impact of long-term subtle changes associated with reduced environmental quality because residents often perceive differences in amenities and their consequences for a short period of time, and fail to recognize slow incremental or evolutionary changes (Freeman Iii, 2003). Also, the method makes use of current prices to make assumptions of future environmental quality level (Hanley, 1992). Since it uses present levels of the amenities in the calculation, people might wrongly expect future levels of those amenities, while discounting potential changes. Hence, the HPM is conservative in that it is a "delayed" response to any changes in the market.

In addition to delayed response in the market, each value described above, use and non-use values, recovers at a different pace. Use value which includes indirect use value like recreational, aesthetic, and spiritual value mostly recovers as the physical aspect of the amenity re-establishes. On the other hand, non-use value which includes existence, bequest, and altruism is related with the consumers' perception of existence and quality. Upon the re-establishment of the physical aspect of amenity, the existence value would start to recover. When the quality of the amenity enhances, consumers' willingness to pay to protect the resource for future generation would increase. The amenity once lost its intrinsic value would slowly recover its original value as the resource recovers its diverse quality both in its existence and its quality.

3.2 Biophilia and Residents' Preference

Evolution has left modern humans with the genetic predisposition to respond positively to nature (McVay et al., 1995; Wilson, 1984). In addition, as matter of survival, humans have evolved to respond quickly to certain settings of nature. This includes restorative responses needed for demanding and stressful environments, and threats and risks encountered in daily life by pre-modern humans (McVay et al., 1995; Ulrich, 1993). McVay et al. (1995); Ulrich (1979) suggests that stressed individuals feel significantly better after exposure to nature scenes rather than to urban scenes. Exposure to nature increases positive effects including feelings of affection, friendliness, playfulness, and elation, especially after excessive exposure to urban scenes and stressors.

McVay et al. (1995) argue that the behavioral predisposition develops from early human effort to survive through habitat selection. The right place provides everything easy and safe; abundant and vulnerable prey, shelters, and surroundings that trick predators and makes it easy for humans to spot possible dangers (Wilson, 1984). Orians (1980) suggested savanna vegetated ecosystem and other early human settlements as supporting evidence. Savannas offered an abundance of food, and the clear view to detect prey and predators in long distances. In many early human settlements, topographic relief that could serve as vantage points like cliffs, hillocks, and ridges were desirable. Lakes and rivers also offered food, and natural perimeter of defense. These elements together form an aesthetic scenery that humans have been depicted in art and landscaping. Landscaping and gardening around the world share similar principles and conditions like trees, shrubs, open space, and streams and ponds (Lockard, 1980; Wilson, 1984).

In addition to preference on nature and landscapes, evolution has affected modern humans in terms of responses to different environmental settings. Modern humans hold the capacity to readily acquire restorative and other healthful responses to certain nature scenes and content. However, there is no such predisposition for most built or artifact-dominated environments and materials such as concrete, glass, or metal (Ulrich, 1993). In a study by Wolf (2005), potential customers claimed increased patronage behavior in places with trees. This includes increased willingness in travel time, travel distance, visit duration and return rates. With proper vegetation, price values for convenience, shopping, and specialty goods were all priced higher. As background to support this result, there are number of studies addressing positive response to nature scenes. Kaplan and Kaplan (1989) presented a result that reveals more nature in a scene evoking higher preference rates. Ulrich (1986) also mentioned that the presence of trees generally enhances public judgment of visual quality in outdoor environments.

In the course of evolution, humans have developed general preference for nature. Humans have a strong tendency to respond positively to nature in terms of their emotional state. On the other hand, many urban environments that are highly complex and lacking nature increase stress levels of individuals and even hampers recuperation (Ulrich et al., 1991). Berlyne (1974) suggests that mid-range complexity in nature and urban setting meets well-being in emotional and physiological states and promotes public preference. As Wilson (1984) argues, the natural world is the ‘refuge of the spirit, remote, static, richer even than human imagination’.

3.3 General Understanding of Key Literature and Direction of the Research

Existing research argues that proximity to natural amenities has positive association with value of a residential property. Urban forests (Tyrväinen, 1997), parks (More et al., 1988), open water (G. Acharya & L.L. Bennett, 2001), beach (S. E. Hamilton & Morgan, 2010), wild life refuge (Neumann et al., 2009), and nature preserves (Thorsnes, 2002) all positively impact property values.

Industrial sites, often regarded as dis-amenities, have negative impact on property values. Proximity to oil and gas facilities (Boxall et al., 2005; Flower & Ragas, 1994), electric transmission lines (S. W. Hamilton & Schwann, 1995), and landfills (Deaton & Hoehn, 2004) are negatively associated with value of residential property.

When the nature preserves and oil wells co-exist, the impact of those dis/amenities on property values will be affected by one another. The existing literature (above) suggests that the nature preserves will have a positive impact and the oil wells will have a negative impact on the value of residential properties. However, when they co-exist, the positive impact of nature preserve may diminish. In the study of residential area in Central Alberta, Canada, Boxall et al. (2005) showed that existence of an oil well within 4km radius of residential properties reduce the value of property by approximately 7%. The authors argued that the existence of an oil well within a certain radius is critical. In the City of Whittier, most residential properties are within 4km radius of the oil well sites. It is expected that those sites negatively impacted the property values and suppressed the positive impact of nature preserves when they were in operation. Thus, when the wells were removed, the positive impact of the nature preserve would be expected to increase. On the other hand, if some of the nature was permanently damaged and has not recovered, it is possible that residents' perception of the mountain may not have changed. In this case, the positive impact of nature may remain unchanged or reduced.

3.4 Hypotheses

The main research question of this study is "How do nature preserves and industrial facilities individually and jointly affect residential properties nearby?" The temporal and spatial scope of this research consists of before and after settings of nature and industry in the City of Whittier, California.

Hypothesis1. The more proximate a residential property is located to nature preserve, the higher premium on the value of the property.

$$\mathrm{H}_0 : \beta_{dn} = 0$$

$$\mathrm{H}_{1a} : \beta_{dn} < 0$$

$$\mathrm{H}_{1b} : \beta_{dn} > 0$$

where β_{dn} indicates the coefficient of impact on sales price of single family housing from distance to nearest nature preserve. The alternate hypotheses will further examine if the effect of distance from the nature preserve is increasing or decreasing.

Hypothesis2. The more proximate a residential property is located to industrial facilities, the more discount on the value of the property before the transformation.

$$\mathrm{H}_0 : \beta_{do} = 0$$

$$\mathrm{H}_{2a} : \beta_{do} < 0$$

$$\mathrm{H}_{2b} : \beta_{do} > 0$$

where β_{do} indicates the coefficient of impact on sales price of single family housing from distance to nearest oil well site before the transformation to the nature preserve. The alternate hypotheses will further examine if the effect of distance from the oil well site is increasing or decreasing.

Hypothesis3. The magnitude of the impact of nature preserve will change after the transformation of oil wells to a nature preserve.

$$\mathrm{H}_0 : \beta_{dn1} = \beta_{dn2}$$

$$\mathrm{H}_{3a} : \beta_{dn1} \neq \beta_{dn2}$$

where β_{dn1} is the coefficient of impact on sales price of single family housing from the distance to the nature preserve before the transformation and β_{dn2} is the coefficient of impact on sales price of single family housing from the distance to the nature preserve after the transformation.

Hypothesis3. The direction of the impact of oil well site will change after the transformation of oil wells to a nature preserve.

$$\mathrm{H}_0 : \beta_{do1} < 0 \; and \; \beta_{do2} > 0$$

$$\mathrm{H}_{3a} : \beta_{do1} < 0 \; and \; \beta_{do2} < 0$$

where β_{do1} is the coefficient of impact on sales price of single family housing from the distance to the oil well site before the transformation and β_{do2} is the coefficient of impact on sales price of single family housing from the distance to the oil well site after the transformation.

CHAPTER IV

METHODS AND DATA

4.1 Study Area

The City of Whittier, California consists of well-defined neighborhoods that share in the long history of being an oil town. The city contains nature preserves, and former oil wells sites, which are located adjacent to residential areas. The residential area is bounded by a forest, a portion of which has been designated as a nature preserve throughout the period of study while another portion had oil wells until 1994. In 1994, the portion of mountainous forestland that had been utilized for oil wells was designated as additional nature preserve. The area for nature preserves and oil well sites are geographically separated as shown in Figure 2.

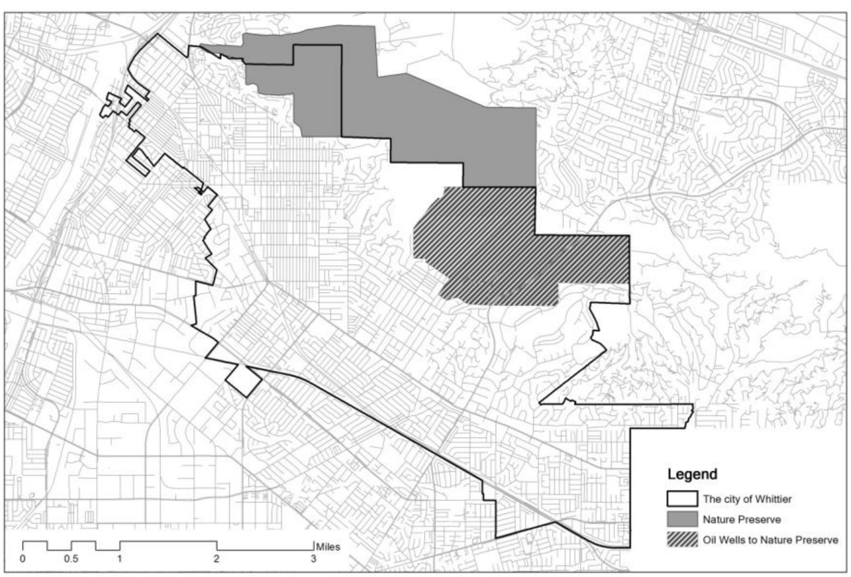


Figure 2 Study area_Whittier CA

4.2 The City of Whittier and Oil

The City of Whittier is bounded by the Whittier hills on the North East, which had been the source of oil since the 1890s. For more than 100 years, oil wells and derricks were drilled in the Whittier hills. In the early years, dozens of small companies like Puente Oil Co., Central Oil Co., and Home Oil Co. began drilling and pumping oil form the hills and shaped development in Whittier and the surrounding areas. In 1918, Shell Oil first brought corporate structure to the oil fields, according to the California Department of Conservation. Following Shell Oil, larger companies began to occupy the hills with as many as 500 wells until the 1980s. With oil prices declining and stringent environmental rules on drilling in the 1980s, Chevron Corp. and Unocal, which had obtained most of the oil well sites from other companies, decided to stop drilling and planned on developing the area with homes. After few years of struggle with the city regarding housing development, the companies sold the land to the city. Hundreds of oil derricks were removed and the land has been reclaimed by nature as a Nature Preserve.

The Whittier hills, managed by the Puente Hills Landfill Native Habitat Authority, is now used for low-impact recreation like hiking and biking. However, oil wells could be returning to the Whittier hills for their economic benefits. With advanced technology and high price of oil, the Whittier hills again became profitable. In 2008, Matrix Oil Co. obtained the lease to drill for oil. The proposed drilling site is on a single site of seven acres, not like hundreds of wells in the past. The city is expected to receive from $7.5 million to $40 million per year from the royalties. As of 2013, there are three lawsuits pending regarding this approval of the oil drilling.

4.3 Geographic Location and Demographics

The City of Whittier is located 12 miles southeast of the City of Los Angeles at the southeast boundary of Los Angeles County. The city boundary encompasses 14.7 square miles. The city has a population of 85,330 residents (United States Bureau of the Census, 2010). The city experienced a substantial growth in 1990s and moderate growth in 2000s with population of 77,800 at the 1990 census and 83,680 at the 2000 census. Despite the changes in population, the number of households has remained remarkably constant ranging from as little as 27,637 in 1990 to as much as 28,270 in 2010, a difference of only around 600 households in 20 years. The city's racial demographic includes 64.6% White, 1.3% African American, 1.3% Native American, 3.8% Asian, and 24.4% others in 2010. The racial composition of the city has remained relatively stable for past 30 years; White has been above 60%, Asians above 3%, African Americans above 1%, Native Americans above 1%, and other above 24%.

According to the 2009 Comprehensive Annual Financial Report, there are total employees of 35,918 in the city. The largest employers are Presbyterian Intercommunity Hospital, Whittier Hospital Medical Center, City of Whittier, Whittier Union High School District, and Whittier College. Major sales tax business clusters are general commercial goods, business and industry, and restaurants and hotels. The city is trying to revitalize Whittier by trying to attract more businesses to Whittwood Town Center and opening new residential town homes in the Uptown district. In addition, Whittier Blvd. is currently under redevelopment based on the master plan adopted in June 2005 by the City Council.

4.4 Data

The datasets were collected across a variety of sources. The historic house sales transaction and building characteristics data were purchased from DataQuick Information Systems for Los Angeles County. Another sales transaction data and parcel map were purchased from the Office of the Assessor, County of Los Angeles. All GIS related data were acquired through Los Angeles County GIS Data Portal (http://egis3.lacounty.gov/dataportal/). Locations of oil wells were geocoded based on historical maps (AMI-LA-83).

4.4.1 Property Value Data

There are several data sources that hold the value of properties. The census reports self-reported home values aggregated to census blocks. Multiple listings service keeps track of sales prices at the parcel level. The Assessor's office of county district keeps records of appraised value and/or sales transaction value. There is also a private company that collects and manages parcel level property data. The home values reported in the census does not represent individual properties as they are aggregated in block-group or above level. Thus, it becomes problematic to use when the unit of the research is a parcel level since the blocks do not participate in markets as a block. The appraised value of the Assessor's office does not precisely represent the market. The assessed value may to some degree reflect the market price, perhaps even being highly correlated, but the assessor's value is not the direct result of a market process, rather an indirect calculation based on Assessor's judgment on the condition of the house. One of the assumptions of hedonic modelling is that it utilizes bid functions of buyers and sellers. The sales price is determined in the market where both buyers and sellers know the conditions of the house and nearby properties and the circumstances of the market. Appraised value lacks these adjustments in the market. Even if the Assessor's office keeps the records of the sales transaction data, it often consists of only the most recent sales for each parcel. Thus, in this research such data was used to cross-validate the information on the sales transaction data purchased from DataQuick, a private company. The sales transaction data from MLS listings service and private companies is costly; nonetheless, the data is more accurate and voluminous. In this research, sales transactions of each parcel between 1986 and 2013 are required. Los Angeles County Assessor's office does not have such historic data and the County's Department of Regional Planning has each copy of the transaction in microfiches. As a result, the historic sales transaction data was purchased from DataQuick, and the data was verified using the data from recent sales obtained from Assessor's Office. Two sets of data were purchased, one holds records of historic sales transactions, including price and other financial details, and the other consists of building structures and specifications. A total of 22,381 sales transactions records were collected from the source in 28 years from 1986 to 2013 in the research.

4.4.2 GIS Data

Parcel data was purchased from the Assessor's office of Los Angeles County. All the other GIS layers were collected from Los Angeles County GIS Data Portal (http://egis3.lacounty.gov/dataportal/). The data includes the location of parks, schools, central business district(s), shopping malls, highways, railways, and golf courses. Changes in parks, schools, and shopping malls have been investigated and adjusted accordingly throughout the time period. Boundary of the nature preserve and sites of oil wells were geocoded based on the aerial photo that was taken in 1983 (AMI-LA-83).

4.4.3 Data Validation

Data validation was done to ensure precision, uniformity, and relevance for accurate measurements of data collected. For the sales transaction data and building structure data, datasets purchased from DataQuick were cross checked with the data acquired from the Assessor's Office. As stated beforehand, the assessor's data in LA County contains only the most recent sales data, but not the historical records of the transactions amount. This was the main reason that the data from DataQuick were purchased. As the result of cross verification, the most recent sales data from the Assessor's Office matched with the sales data purchased from DataQuick. All the GIS related data were checked with satellite maps. Changes in parks, schools, and shopping malls were confirmed with City's record, Los Angeles County GIS portal, and historic satellite maps.

4.4.4. Data Integrations and Treatment

Data generation, integration and treatment were conducted in STATA 12, ArcMap

10, and its extensions. ArcMap and the extension were used to delineate the study areas, study the data spatially, and conduct distance measurements. The sales and property information was combined with neighborhood and locational information using STATA12 and ArcGIS 10.2.

Sales transactions of properties were combined to parcel maps with associated attribute tables in ArcMap. A new dataset that only contains parcels with sales transactions were created. Every sales transactions data were included in the hedonic modelling except for the spatial models. Spatial models allow only one transaction for each location, the parcel, in the calculation. Thus, for each 2 year period, the most recent transactions were employed in the spatial hedonic models. This eliminated 2580 sales transactions in the entire study period, which is 12.4% of all the sales transactions. The locational attributes were then calculated. Euclidean distances between the properties and the dis/amenities were calculated using distance calculation function in spatial analyst in ArcMap. Network distances between the properties and entrances to dis/amenities like the nature preserve, shopping malls or the nearest highway entrance were measured in Arc View's Network Analyst. Upon the completion of creating values for locational variables, the data was joined to other attributes provided in the secured basic file(DS04), which was purchased from Assessors Office of Los Angeles County. The secured basic file (DS04) contains information about structures and conditions of each property such as year built, year(s) of sale, parcel area, number of rooms, and etc. The combined data were investigated to treat cases with missing or spurious values either by deleting it or creating scales of the related variables depending on the situation.

Data with figures above 3 standard deviation and/or missing values were removed.

4.4.5. Basic Statistical Analysis

Descriptive statistics, mean and median, minimum and maximum values, and their standard deviations, were employed. For continuous variables, histograms were initially used to display the distribution of each variable, which shows some sense of normality and extreme outliers. Then, these variables were analyzed for normality using standard measures of skewness and kurtosis. Using descriptive statistics properties were identified depending upon their locations relative to the nature preserve and the oil well site. For example, properties adjacent to the nature preserves were compared to properties adjacent to oil wells.

Zero-Order Pearson's correlation coefficients were utilized, and for ordinal or dichotomous variables, Spearman's rho was used. Upon the examination of correlation, variables with correlation higher than 0.70 or above were identified for further analysis. To confirm multicollinearity, the Variance Inflation Factor, VIF, was used in addition to correlation. Some of the items were deleted in order to eliminate concerns of multicollinearity and give a more robust statistical estimate model.

4.5 Variables and Measurements

4.5.1 Dependent Variables

Among various estimates of property value such as the actual market value of a property, the assessed value, and the average value of all homes within a census unit, the actual market price is the preferred measure of value since it directly reflects individuals' allocations of spending among a range of other alternatives formed by competing home buyers' valuations of the houses in the market. Rosen (1974) argues market equilibrium as characteristics of a market formed with perfectly competitive profit-maximizing producers and utility-maximizing consumers. The assessed values and average value from census do not satisfy this assumption of hedonic price modeling. Assessed values often reflect assessors' opinions and perspectives, which biases the value of the property and provides an inaccurate picture of market condition (Darling, 1973). Even if assessed values were found to be correlated with sales values, assessed values are at best an indirect, and potentially biased, reflection of market driven prices/values.

It is for these reasons that this dissertation uses actual sales data. For an accurate representation of the individual housing markets, extreme data, beyond 2 standard deviations from the mean, were examined more closely to assure data appropriately represent the market rather than being unduly influenced by extreme extraordinary cases in the geographical area. (Taff, Tiffany, & Weisberg, 1996). All sales prices were adjusted to 2013 U.S. dollars using Consumer Price Index from Bureau of Labor Statistics. Sales data for 20,733 transactions in 28 years comprise the data for this research, which averages 774 transactions a year. These sales transactions include all the multiple sales transactions on a single property as well. For the spatial hedonic modelling the most recent transactions were employed. This eliminated 2,580 sales transactions in the entire study period, which is 12.4% of all the sales transactions.

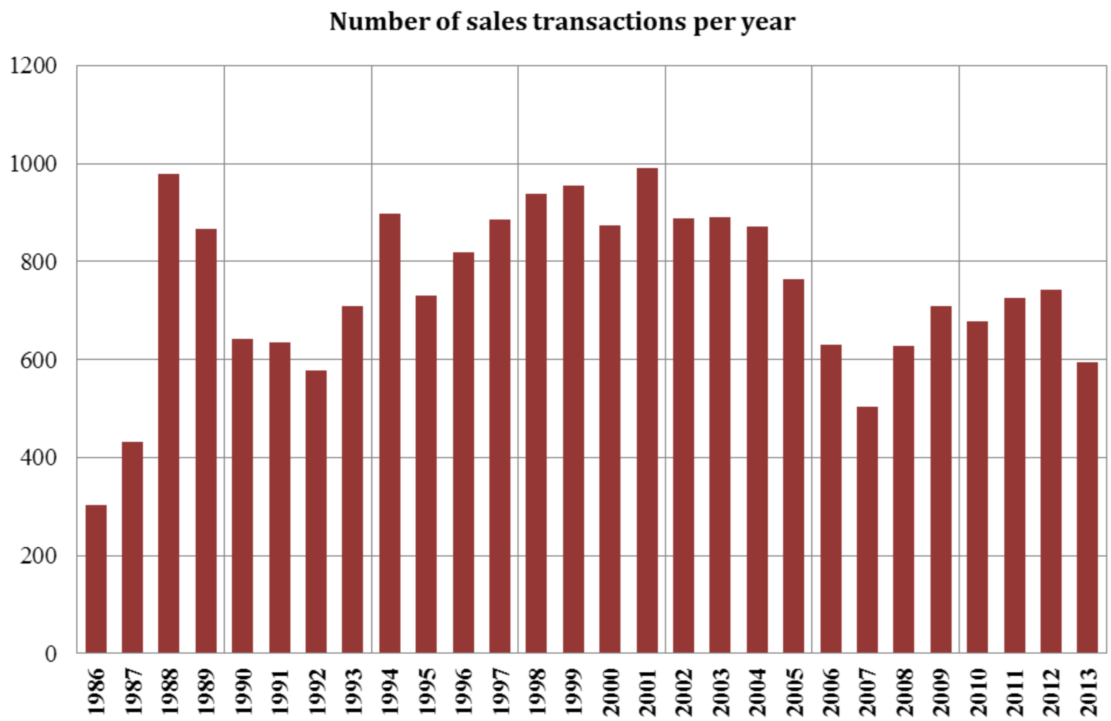


Figure 3 Number of sales transactions per year

4.5.2 Independent Variable

The independent variables for this study involve the distances between nature preserve/oil wells and properties and were measured as Euclidean and network distances. Network distance is more appropriate for amenities where residents visit and enjoy like recreational parks, and Euclidean distance is more appropriate for amenities that residents enjoy the view and environmental benefits of open spaces passively (Poudyal, Hodges, Tonn, & Cho, 2009). The City of Whittier has a grid type road network throughout the city, which allows this analysis to unify the measures for all locational attributes as Euclidean distances. The grid type road network makes Network distances and Euclidean distances highly correlated. ArcMap was used to acquire the Euclidean distance from each house to the nearest boundaries (Donovan & Butry, 2011; More et al., 1988). View is comprised of having a view (e.g., not being blocked) and distance (e.g., presumably closer affords greater detail and is as such better). View of nature preserve and oil well sites were examined using viewshed analysis in ArcMap. DEM, the elevation data, was acquired from USGS. Once the existence of a view to the nature preserve or the oil well sites was determined, 0 or 1, the binary variable was multiplied by the inverse of the corresponding distance.

In addition to the independent variables, other variables that are closely related to the valuation of residential property were determined. Selection of such variables was based upon a review of factors considered relevant in previous studies. Seventy-five previous studies were reviewed in terms of the Hedonic models they used. The variables regarding structural, neighborhood, and locational attributes in 75 previous studies are shown in Table 3. Generally, independent variables used more frequently in these studies are considered more important to account for in this study. This means that it is probably very important to take lot size, age and house size into consideration, but less important to take into account power lines, other parking and swimming pools.

Table 3 Variables utilized in 75 Previous Hedonic Studies

Characteristics	Times used (n=75)	Examples of Variables
Lot		
Lot size	55	Lot size
Lot characteristics	6	Lot shape, width, depth
Structure		
Age	53	House age
House size	51	House size
Bedrooms	46	Number of bedrooms
Bathrooms	45	Number of bathrooms
Garages	43	Existence, number
Fireplaces	30	Existence, number
Quality/Condition of House	27	Structural and visual
Heating/Air Conditioning	25	Existence, type
Backyard/front yard	25	Existence, size
Basement	17	Existence
House type	15	Architectural style, detached, condo, etc
Rooms	14	Average size
Other exterior features	13	Decks, patios, porches, etc
Number of stories	13	Number
Exterior materials	13	Wall, roof material
Swimming pool	10	Existence
Other parking	8	Carport, driveway
Time of sale	50	Year or month of sale
Locational		
Natural amenities	50	Distance to parks, greenways, rivers, etc
Schools	29	Distance
Central business districts	25	Distance
Shopping malls	22	Distance
Historic District	11	Distance
major highways	10	Distance
power lines	4	Distance
Neighborhood		
surrounding land uses	15	Proportions or views of different uses
Public Utilities & Services	11	Public water, sewer, expenditures, etc
Neighborhood Quality	4	-
Land regulation	17	Property tax rate, deed, etc
location	25	Different subdivisions, districts, etc

4.5.3 Structural Variable

For structural characteristics of a single family house, variables such as size of lot and house, numbers of rooms and bathrooms, age of house, existence of garages and swimming pool, vacancy, and enrollment in Mills Act program were employed (Bolitzer & Netusil, 2000; Crompton, 2005; J. Geoghegan et al., 2003; Rosen, 1974). Age of the house at the time of sale was calculated by subtracting built year from the year the house was sold. Mills Act program provides the property owner the tax abatement for participating in the restoration and maintenance of qualified historic properties. Houses enrolled in this program hold extra aesthetic value as historic buildings and also are generally well maintained.

Table 4 Measures of Structural Variables

Variable		Measure
Structural	*SQFT*	Number of square feet in the house
	LOTSIZE	Number of square feet in the lot
	NBR_BATH	Number of bathrooms
	ln_ NBR_BATH	Log of Number of bathrooms
	NBR_BEDRMS	Number of bedrooms
	ln_ BR_BEDRMS	Log of Number of bedrooms
	AGE	Age of the house in years
	D_pool	Dummy variable for the presence of a pool
	D_spa	Dummy variable for the presence of a spa
	D_vacant	Dummy variable for the vacancy of the house
	D_MillsAct	Dummy variable for enrollment in Mills Act program

4.5.4 Locational Variable

For variables other than housing characteristics, proximity to dis/amenities such as parks, schools, golf courses, and shopping malls were included (Bastian et al., 2002; Neumann et al., 2009; Tapsuwan et al., 2009). As stated above in the dependent variable section, all distance variables were unified into Euclidean distances (Donovan & Butry, 2011; More et al., 1988). Among all the parks, parks with fewer parking spaces, lower crime rate, and smaller size were selected. Large parking lots indicate that many users come from some distance away to use the park, while smaller parks are often associated with neighborhoods and even become a part of neighborhood identification (Clarke, 1997; Groff & McCord, 2012).

Table 5 Measures of Locational Variable

Variable		Measure
Locational	*DIST_Shop*	Distance to nearest shopping mall
	DIST_ES	Distance to nearest elementary school
	DIST_parks	Distance to nearest park
	DIST_golf	Distance to nearest golf course

4.5.5 Neighborhood Variable

In addition to locational variables, a neighborhood variable, diversity index of land use, was introduced to account for spatial differences. The diversity index describes distribution and diversity of land use within each neighborhood. Neighborhood boundaries associated with realtor information were employed after validating with census boundaries. Diversity index, a measure of how diverse land use is within a certain area, indicates whether an area is dominated by a few land uses (Jacqueline Geoghegan et al., 1997). In this study, Simpson's Diversity index (Bastian et al., 2002) was employed where D is the diversity index ranging from 0 to 1(lower value representing less diversity). The equation is as follows,

$$D = 1 - \sum_{i=1}^{l} (p_i)^2$$

where i is land use type, and p_i is the proportion of land use occupied by each land use type in a neighborhood. The more land-use types there are and the more similar their proportions, the greater the diversity (G. Acharya & L.L. Bennett, 2001).

Table 6 Measures of Neighborhood Variable

Variable		Measure
Neighborhood	*SD_100*	Simpson's Diversity index (0-1) multiplied by 100
	D_highway	Dummy variable for location within 1/4 mile of the major highway

4.5.6 Variables and Expected Signs

The variables utilized in this study and their types, either dichotomous or continuous, are listed in Table 7. It also displays the expected sign on the regression coefficient of each variable.

Table 7 Variables selected in this study

Variable		Hypothesized sign	Variable description/definition
Independent	*ln_VALUE*	(dependent)	Log of selling price of house
	DIST_NP	Negative	Distance to Nature Preserve in mile
	DIST_OW	Positive	Distance to oil wells in mile
	VIEW_NP	Positive	Dummy for the presence of a view to nature preserve multiplied by inverse of the distance
	VIEW_OW	Negative	Dummy for the presence of a view to oil well sites multiplied by inverse of the distance
Structural	*SQFT*	Positive	Number of square feet in the house
	LOTSIZE	Positive	Number of square feet in the lot
	NBR_BATH	Positive	Number of bathrooms
	NBR_BEDRMS	Positive	Number of bedrooms
	AGE	Negative	Age of the house in years
	D_pool	Positive	Dummy variable for the presence of a pool
	D_spa	Positive	Dummy variable for the presence of a spa
	D_vacant	Negative	Dummy variable for the vacancy of the house
	D_MillsAct	Positive	Dummy variable for enrollment in Mills Act program
Locational	*DIST_Shop*	Positive	Distance to nearest shopping mall
	DIST_ES	Negative	Distance to nearest elementary school
	DIST_parks	Negative	Distance to nearest park
	DIST_golf	Negative	Distance to nearest golf course
Neighborhood	*SD_100*	Positive	Simpson's Diversity index (0-1) multiplied by 100
	D_highway	Negative	Dummy variable for location within 1/4 mile of the major highway
	YD_#		Dummy variable for year

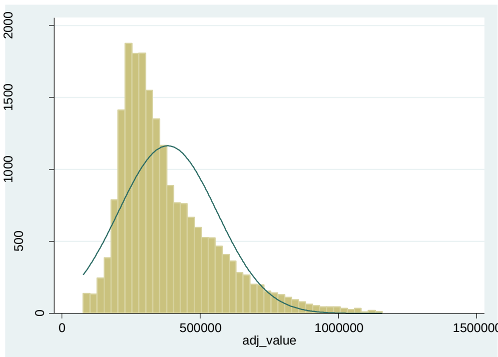
CHAPTER V

DESCRIPTIVE STATISTICS AND MODEL SPECIFICATION

This study uses 20,407 sales transactions in the City of Whittier in the 28 years period. The cross-sectional datasets are constructed for fourteen 2-year periods from 1986 to 2013. Each dataset consists of structural, neighborhood and locational variables associated with individual properties and their associated sales transactions. Descriptive analyses for all variables were conducted in full and in 2-year periods to examine the data characteristics and distribution.

5.1 Sales Transaction

As discussed in the Chapter 3 on hedonic literature, hedonic modelling requires transformation of dependent variables and explanatory variables, usually sales transaction values, to concur with the principle of goodness of fit. Figure 4 and 5 show the histograms of the dependent variable, sales price, before and after the log transformation. Log-transformed sales price conforms more closely to the normal distribution. The number of sales transactions employed in this study is 20,407. Table 8 presents the minimums, maximums, means, and standard deviations of variables in this study. Since 1986, the average sales price of a single family house, adjusted to 2013 dollars, is $378,909 in the City of Whittier. Sales prices in the city of Whittier ranged from S76,968 to $1,158,547, in constant 2013 dollars.



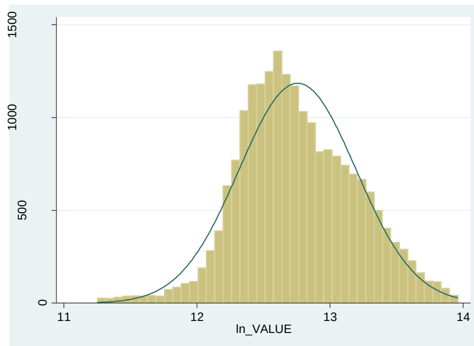


Figure 4 Histogram of sales price

Figure 5 Histogram of log sales price

5.2 Distance and View: Nature Preserve and Oil Well Site

The average distance from the sold properties to the Nature Preserve and the oil well sites is 1.91 miles and 1.51 miles respectively. The former oil well site is more centrally located than the Nature Preserve. Distance to the boundary of the nature preserve varied from adjacent properties to 4.6 miles (Euclidean distance). Distance to the oil well site ranged from adjacent properties to 3.3 miles (Euclidean distance). There are not any variables highly correlated with these distance variables; the absolute value of all zero-order Pearson correlations are less than 0.5. Among the properties, the mean value of visibility of the nature preserve is higher than that of the former oil well sites. The viewshed variables are not highly correlated with any other variables.

5.3 Structural Characteristics

An average single family house has 1,582 square foot living area, built on a 8,354 square foot lot, three bedrooms, and two bathrooms. On average, the properties were 50 years old when they were sold. Lot size varied from 1,516 square feet to 29,996 square feet, and living area ranged from 384 square feet to 5,995 square feet. Number of rooms ranged from one bedroom, and one bathroom, to eight bedrooms, and seven bathrooms. Nineteen percent of the properties had pools and eight-five percent had garages. Generally, structural characteristics variables are more correlated than others. Size of the house and the number of bathroom were highly correlated at 0.81.

Table 8 Descriptive Statistics of Properties

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.75	0.44	11.25	13.96
VALUE	378909	174635	76968	1158547
DIST_NP	1.91	1.19	0	4.60
DIST_OW	1.52	0.74	0	3.31
VIEW_NP_INT	1.28	6.52	0	100.00
VIEW_OW_INT	0.94	5.95	0	100.00
ln_SQFT	7.30	0.36	5.95	8.70
SQFT	1581.52	641.36	384	5995
ln_LOTSIZE	8.94	0.39	7.32	10.31
LOTSIZE	8349.89	4317.29	1516	29996
NBR_BATH	1.88	0.80	1	7
NBR_BEDRMS	3.00	0.82	1	8
AGE	50.83	15.99	0	128
D_pool	0.19	0.39	0	1
D_spa	0.01	0.10	0	1
D_vacant	0.00064	0.025	0	1

Table 8 continued

Variable	Mean	Std. Dev.	Min	Max
D_MillsAct	0.0017	0.041	0	1
D_garage	0.85	0.35	0	1
DIST_Shop	0.52	0.29	0	1.75
DIST_ES	0.33	0.20	0	1.21
DIST_Park	0.50	0.31	0	1.49
DIST_golf	1.57	0.59	0	3.10
SD_100	26.58	19.78	0	82.37
D_highway	0.021	0.14	0	1

Table 9 Correlation of Variables

	ln_VALUE	DIST_NP	DIST_OW	VIEW_NP	VIEW_OW	SQFT	LOTSIZE	NBR_BATH	NBR_BE~S	AGE	D_pool	D_spa	D_vacant	D_Mill~t	D_garage	DIST_S~p	DIST_ES	DIST_park	DIST_g~f	SD_100	D_high~y
ln_VALUE	1																				
DIST_NP	0.0111	1																			
DIST_OW	-0.2767	-0.0908	1																		
VIEW_NP	-0.2408	-0.283	0.2725	1																	
VIEW_OW	-0.0014^	0.3394	-0.313	0.1715	1																
SQFT	0.4706	-0.0355	-0.3422	-0.2766	-0.0222	1															
LOTSIZE	0.4096	-0.0187^	-0.3298	-0.2662	0.0119^	0.6035	1														
NBR_BATH	0.4217	0.0571	-0.282	-0.2839	-0.0019^	0.8113	0.49	1													
NBR_BEDRMS	0.3179	0.1457	-0.1998	-0.185	0.0364	0.6164	0.3103	0.6068	1												
AGE	-0.1043	-0.2556	0.1288	0.2492	-0.1254	-0.4061	-0.274	-0.4212	-0.3008	1											
D_pool	0.2531	0.0835	-0.1666	-0.1825	0.018^	0.3403	0.2991	0.3207	0.2571	-0.1995	1										
D_spa	0.0438	-0.0063^	-0.0272	-0.0353	-0.0216	0.0516	0.0185	0.0499	0.0302	-0.0307	-0.0425	1									
D_vacant	-0.0337	-0.0068^	0.0032^	0.0077^	0.0029^	-0.007^	0.0206	0.0008^	-0.0071^	0.0165	0.0059^	-0.0026^	1								
D_MillsAct	0.0359	-0.0465	-0.0281	0.0207	-0.0233	0.0491	0.0278	0.0211^	0.0404	0.0719	0.0022^	-0.0043^	-0.0011^	1							
D_garage	-0.0158^	-0.1506	0.0456	0.0892	-0.0168	-0.1061	-0.048^	-0.0901	-0.0575	0.0569	-0.035	-0.0035^	-0.0307	-0.0079^	1						
DIST_Shop	0.2735	0.167	-0.3438	-0.2725	0.0872	0.3899	0.3417	0.3274	0.2701	-0.3296	0.2229	0.036	-0.0055^	-0.0161^	0.0039	1					
DIST_ES	0.2529	0.0477	-0.374	-0.2232	0.1632	0.3869	0.3407	0.3166	0.221	-0.284	0.1417	0.0317	-0.0001^	-0.0044^	0.0211	0.4729	1				
DIST_Park	-0.1513	-0.0746	0.4192	0.0652	-0.0696	-0.1379	-0.0822	-0.1221	-0.1054	-0.0476	-0.0664	-0.0185	0.0183	-0.0318	-0.0063^	-0.0737	-0.2197	1			
DIST_golf	-0.3902	-0.3905	0.3759	0.4411	-0.2025	-0.4236	-0.4145	-0.4174	-0.2919	0.4081	-0.2759	-0.0338	0.0282	0.0365	0.0199^	-0.3531	-0.4674	0.2471	1		
SD_100	-0.0913	-0.4179	0.2069	0.1778	-0.2671	-0.0369	-0.0804	-0.0473	-0.0991	0.3101	-0.104	-0.0136	0.024	0.0525	-0.0457	-0.242	-0.1941	0.0587	0.5466	1	
D_highway	-0.0279	-0.1488	0.3261	0.0495	-0.1134	-0.0275	-0.0195	-0.0069^	-0.0119^	-0.0317	-0.0059^	-0.0148	-0.0038^	-0.0062^	0.0463	-0.0138^	-0.0284	0.2957	-0.0529	0.0198	1

^ denotes insignificance of the correlation

5.4 Locational Characteristics

For an average single family house, an elementary school is located within 1/3 mile radius. Parks and shopping malls are around 1/2 mile apart from the residential properties on average. Golf course is the only facility that is located outside of 1 mile radius on average. Distance to the elementary school ranged from 0 mile to 1.21 miles (Euclidean distance). Distance to the shopping mall, park, and golf course ranged from being adjacent to 1.75 miles, 1.49 miles, and 3.10 miles, respectively. Elementary school, parks, and shopping malls are relatively easier to access than golf courses in the city. There are no locational variables that are highly correlated with other variables in the study. The highest level of correlation is between distance to shopping mall and distance to elementary school at 0.4729, which is below the threshold for concern with respect to multicolinearity.

5.5 Neighborhood Characteristics

The diversity index measures how diverse land use is within a certain area. Lower value represents less diversity (relative to the number of various types/groups). On average, neighborhoods have diversity index of 26.58. The lower the diversity index the more the neighborhood is dominated by fewer land uses. The neighborhood with the maximum value of diversity index has 82.38, which indicates more and even uses of land uses in the area; while the minimum diversity index is 0 which indicates high concentrations within a few types. There are 2% of the residential properties within 1/4 mile from the major highway. For both variables, no significantly high correlation with other variables is reported.

5.6 Correlation Analysis

The zero-order Pearson's correlation shows the associations among pairs of variables. Correlations quantify the strength of the associations among variables and may be used to detect possible collineaity issues among explanatory variables. Correlations above 0.7 may further be examined with variance inflation factor and tolerance value in hedonic models. Number of bathrooms and square feet of house is highly correlated and it needs to be carefully checked with VIF in the hedonic models. In terms of correlation between logged sales price and other variables, no correlations of concern were found.

All the variables are significantly correlated with the sales price except for view of oil well sites and the existence of a garage. The variable of interest, distance to nature preserve and oil well sites, shows positive and negative correlation respectively. This is contrary to the expected result, as the nature preserve is thought to be an amenity. Also, view of nature preserve and oil well site reveals negative correlation with the sales price. These will be further investigated through the hedonic modelling.

As presented in the literature, all the building structural variables are highly and positively correlated with the sales price. Correlations between the sales price and size of house and lot, and number of bathroom are above 0.4; number of bedrooms is at 0.318; age of the house is negatively correlated with the sales price and existence of pool and spa is a positive. Joining Mills Act program is positively correlated with the sales price.

Among locational variables, distance to park and golf course are negatively correlated with the sales price, which represents a positive association as it gets closer. Distance to shopping is positively correlated with the sales price, which means negative association. Distance to elementary school reveals an unexpected correlation. Previous literature showed positive association between sales price and proximity to schools. As the data set represents a 28 year span, it will be analyzed carefully in subsets of periods.

Diversity index is negatively correlated with the sales price. Hence the more diverse in the land use of the neighborhood the lower the price. Also, location within 1/4 mile of major highway is negatively correlated with the value of the house.

5.7 Descriptive Statistics in Two-Year Periods

Descriptive statistics for each period reveals that most of the variable shares similar average values and standard deviations throughout the study period. Sharing similar characteristics and distributions of sold properties in each period means that it is comparable among the periods. Even after the sales transaction values were adjusted to 2013 dollars using CPI, there is gradual increase in the price of single family residential properties. The average sales price in 1986 and 1987 was 286,903 dollars. The average price increases until 2007 to 631,174 dollars and decreases and bounces back to 401,201 dollars in the year 2012 and 2013.

Table 10 Descriptive Statistics of Properties sold in 1986-1987

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.49	0.38	11.26	13.84
VALUE	286903	120606	77941	1020250
DIST_NP	1.83	1.17	0	4.57
DIST_OW	1.46	0.78	0	3.29
VIEW_NP	0.57	0.50	0	1
VIEW_OW	0.37	0.48	0	1
SQFT	1710.71	684.34	589	5704
LOTSIZE	8963.25	4512.82	3303	29996
NBR_BATH	2.01	0.80	1	6
NBR_BEDRMS	3.08	0.81	1	6
AGE	35.27	11.97	0	85
D_pool	0.20	0.40	0	1
D_spa	0.019	0.14	0	1
D_vacant	0.0017	0.041	0	1
D_MillsAct	0.0034	0.059	0	1
D_garage	0.95	0.22	0	1
DIST_Shop	0.55	0.30	0	1.72
DIST_ES	0.34	0.22	0	1.15
DIST_parks	0.50	0.31	0	1.44
DIST_golf	1.50	0.60	0	2.85
SD_100	25.64	18.26	0	82.37
D_highway	0.021	0.14	0	1

Table 11 Descriptive Statistics of Properties sold in 1988-1989

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.66	0.43	11.27	13.94
VALUE	346251	159179	78768	1127211
DIST_NP	1.83	1.15	0	4.59
DIST_OW	1.51	0.73	0	3.30
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.38	0.48	0	1
SQFT	1619.46	748.74	456	5995
LOTSIZE	8389.34	4488.65	1900	29436
NBR_BATH	1.93	0.87	1	7
NBR_BEDRMS	3.02	0.86	1	7
AGE	39.77	14.60	0	98
D_pool	0.21	0.40	0	1
D_spa	0.011	0.10	0	1
D_vacant	0.00055	0.02	0	1
D_MillsAct	0.0017	0.04	0	1
D_garage	0.91	0.28	0	1
DIST_Shop	0.53	0.30	0	1.73
DIST_ES	0.34	0.22	0	1.21
DIST_parks	0.50	0.32	0	1.44
DIST_golf	1.60	0.62	0	3.10
SD_100	26.87	20.14	0	82.37
D_highway	0.019	0.14	0	1

Table 12 Descriptive Statistics of Properties sold in 1990-1991

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.74	0.38	11.25	13.96
VALUE	367448	150805	76968	1158547
DIST_NP	1.88	1.20	0	4.51
DIST_OW	1.54	0.76	0	3.30
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.35	0.48	0	1
SQFT	1571.64	638.09	472	5831
LOTSIZE	8149.81	4116.06	1990	29556
NBR_BATH	1.87	0.82	1	7
NBR_BEDRMS	2.98	0.84	1	6
AGE	42.18	13.81	0	101
D_pool	0.19	0.39	0	1
D_spa	0.012	0.11	0	1
D_vacant	0	0	0	0
D_MillsAct	0.0024	0.049	0	1
D_garage	0.90	0.30	0	1
DIST_Shop	0.53	0.29	0	1.73
DIST_ES	0.33	0.21	0	1.16
DIST_parks	0.51	0.31	0	1.43
DIST_golf	1.57	0.59	0	3.09
SD_100	27.04	19.75	0	82.37
D_highway	0.029	0.17	0	1.00

Table 13 Descriptive Statistics of Properties sold in 1992-1993

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.62	0.36	11.26	13.78
VALUE	323847	122570	77675	964877
DIST_NP	1.93	1.21	0	4.60
DIST_OW	1.51	0.74	0	3.31
VIEW_NP	0.56	0.50	0	1
VIEW_OW	0.35	0.48	0	1
SQFT	1594.82	636.30	384	5204
LOTSIZE	8346.08	4253.33	1516	29484
NBR_BATH	1.92	0.80	1	5
NBR_BEDRMS	3.02	0.86	1	7
AGE	43.49	13.65	0	103
D_pool	0.19	0.39	0	1
D_spa	0.014	0.12	0	1
D_vacant	0.0016	0.040	0	1
D_MillsAct	0.0016	0.040	0	1
D_garage	0.86	0.35	0	1
DIST_Shop	0.52	0.28	0	1.70
DIST_ES	0.32	0.20	0	1.18
DIST_parks	0.50	0.30	0	1.49
DIST_golf	1.55	0.58	0	3.05
SD_100	26.61	19.98	0	82.37
D_highway	0.02	0.13	0	1

Table 14 Descriptive Statistics of Properties sold in 1994-1995

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.52	0.37	11.29	13.92
VALUE	294643	124240	80069	1111740
DIST_NP	1.93	1.20	0	5
DIST_OW	1.52	0.74	0	3
VIEW_NP	0.56	0.50	0	1
VIEW_OW	0.38	0.49	0	1
SQFT	1637.90	658.78	456	5840
LOTSIZE	8615.17	4502.38	1823	29556
NBR_BATH	1.94	0.81	1	6
NBR_BEDRMS	3.05	0.83	1	6
AGE	45.71	13.68	0	105
D_pool	0.22	0.42	0	1
D_spa	0.0093	0.10	0	1
D_vacant	0.00062	0.02	0	1
D_MillsAct	0.0019	0.04	0	1
D_garage	0.84	0.37	0	1
DIST_Shop	0.52	0.29	0	1.74
DIST_ES	0.33	0.20	0	1.15
DIST_parks	0.51	0.32	0	1.46
DIST_golf	1.55	0.61	0	3.04
SD_100	27.04	19.36	0	82.37
D_highway	0.023	0.15	0	1

Table 15 Descriptive Statistics of Properties sold in 1996-1997

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.43	0.37	11.25	13.89
VALUE	268147	119086	77009	1076443
DIST_NP	1.91	1.18	0	4.60
DIST_OW	1.52	0.74	0	3.28
VIEW_NP	0.55	0.50	0	1
VIEW_OW	0.37	0.48	0	1
SQFT	1625.90	681.15	589	5776
LOTSIZE	8663.38	4765.43	2052	29574
NBR_BATH	1.90	0.83	1	6
NBR_BEDRMS	3.01	0.88	1	7
AGE	47.83	14.52	0	101
D_pool	0.22	0.41	0	1
D_spa	0.0066	0.081	0	1
D_vacant	0.00060	0.02	0	1
D_MillsAct	0.0030	0.05	0	1
D_garage	0.84	0.37	0	1
DIST_Shop	0.53	0.29	0	1.73
DIST_ES	0.33	0.21	0	1.20
DIST_parks	0.50	0.31	0	1.49
DIST_golf	1.57	0.61	0	3.09
SD_100	27.07	20.28	0	82.37
D_highway	0.019	0.14	0	1.0

Table 16 Descriptive Statistics of Properties sold in 1998-1999

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.51	0.37	11.29	13.86
VALUE	292369	128077	79703	1048726
DIST_NP	1.89	1.18	0	4.57
DIST_OW	1.47	0.74	0	3.31
VIEW_NP	0.57	0.50	0	1
VIEW_OW	0.37	0.48	0	1
SQFT	1636.71	667.77	576	5863
LOTSIZE	8536.33	4545.88	1967	29733
NBR_BATH	1.94	0.81	1	7
NBR_BEDRMS	3.05	0.82	1	7
AGE	49.27	14.94	0	109
D_pool	0.20	0.40	0	1
D_spa	0.012	0.11	0	1
D_vacant	0.0011	0.033	0	1
D_MillsAct	0.0027	0.052	0	1
D_garage	0.85	0.36	0	1
DIST_Shop	0.53	0.30	0	1.75
DIST_ES	0.34	0.21	0	1.18
DIST_parks	0.49	0.30	0	1.46
DIST_golf	1.55	0.61	0	3.07
SD_100	26.47	19.90	0	82.37
D_highway	0.019	0.14	0	1.00

Table 17 Descriptive Statistics of Properties sold in 2000-2001

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.62	0.35	11.38	13.96
VALUE	322793	130256	87934	1149904
DIST_NP	1.89	1.19	0	4.60
DIST_OW	1.51	0.74	0	3.30
VIEW_NP	0.57	0.49	0	1
VIEW_OW	0.37	0.48	0	1
SQFT	1587.16	639.39	601	5790
LOTSIZE	8348.26	4398.65	2065	29722
NBR_BATH	1.88	0.80	1	7
NBR_BEDRMS	2.99	0.83	1	7
AGE	51.58	14.65	0	110
D_pool	0.20	0.40	0	1
D_spa	0.0082	0.090	0	1
D_vacant	0.00055	0.023	0	1
D_MillsAct	0.0016	0.040	0	1
D_garage	0.84	0.37	0	1
DIST_Shop	0.52	0.28	0	1.71
DIST_ES	0.33	0.20	0	1.21
DIST_parks	0.49	0.30	0	1.45
DIST_golf	1.56	0.58	0	3.06
SD_100	26.46	19.85	0	82.37
D_highway	0.020	0.14	0	1

Table 18 Descriptive Statistics of Properties sold in 2002-2003

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.87	0.36	11.41	13.93
VALUE	416581	163893	90645	1126803
DIST_NP	1.85	1.18	0	4.49
DIST_OW	1.52	0.77	0	3.30
VIEW_NP	0.59	0.49	0	1
VIEW_OW	0.38	0.48	0	1
SQFT	1583.57	649.14	456	5806
LOTSIZE	8412.44	4431.09	1823	29811
NBR_BATH	1.88	0.82	1	7
NBR_BEDRMS	2.99	0.83	1	7
AGE	53.99	14.46	0	108
D_pool	0.18	0.39	0	1
D_spa	0.010	0.10	0	1
D_vacant	0	0	0	0
D_MillsAct	0.0011	0.03	0	1
D_garage	0.85	0.36	0	1
DIST_Shop	0.52	0.29	0	1.75
DIST_ES	0.33	0.21	0	1.21
DIST_parks	0.50	0.30	0	1.43
DIST_golf	1.56	0.58	0	3.07
SD_100	26.37	19.86	0	82.37
D_highway	0.023	0.15	0	1.00

Table 19 Descriptive Statistics of Properties sold in 2004-2005

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	13.22	0.28	11.83	13.95
VALUE	572162	162431	137174	1140737
DIST_NP	1.93	1.21	0	4.51
DIST_OW	1.56	0.72	0	3.30
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.38	0.49	0	1
SQFT	1502.10	548.72	504	5573
LOTSIZE	7927.75	3771.74	1890	28513
NBR_BATH	1.80	0.73	1	5
NBR_BEDRMS	2.94	0.77	1	6
AGE	55.99	14.03	0	112
D_pool	0.15	0.35	0	1
D_spa	0.0074	0.086	0	1
D_vacant	0.00062	0.02	0	1
D_MillsAct	0.0012	0.04	0	1
D_garage	0.82	0.38	0	1
DIST_Shop	0.50	0.27	0	1.51
DIST_ES	0.32	0.19	0	1.21
DIST_parks	0.50	0.31	0	1.45
DIST_golf	1.60	0.55	0	2.95
SD_100	27.34	20.14	0	82.37
D_highway	0.020	0.14	0	1

Table 20 Descriptive Statistics of Properties sold in 2006-2007

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	13.32	0.28	11.27	13.96
VALUE	631174	158822	78648	1155541
DIST_NP	1.93	1.20	0	4.56
DIST_OW	1.54	0.73	0	3.30
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.38	0.49	0	1
SQFT	1491.32	508.60	472	4990
LOTSIZE	7964.41	3742.54	1607	29305
NBR_BATH	1.76	0.69	1	5
NBR_BEDRMS	2.93	0.74	1	6
AGE	57.29	13.65	0	106
D_pool	0.16	0.37	0	1
D_spa	0.010	0.10	0	1
D_vacant	0	0	0	0
D_MillsAct	0.00089	0.03	0	1
D_garage	0.83	0.37	0	1
DIST_Shop	0.51	0.26	0	1.49
DIST_ES	0.31	0.19	0	1.15
DIST_parks	0.51	0.33	0	1.49
DIST_golf	1.59	0.55	0	2.92
SD_100	26.08	19.48	0	82.37
D_highway	0.028	0.16	0	1.00

Table 21 Descriptive Statistics of Properties sold in 2008-2009

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.92	0.35	11.55	13.95
VALUE	433717	159233	103872	1140152
DIST_NP	2.01	1.19	0	4.60
DIST_OW	1.59	0.72	0	3.29
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.36	0.48	0	1
SQFT	1516.88	571.71	407	5012
LOTSIZE	8151.19	4064.32	2434	29484
NBR_BATH	1.82	0.74	1	6
NBR_BEDRMS	2.96	0.78	1	7
AGE	59.13	13.35	0	121
D_pool	0.18	0.39	0	1
D_spa	0.01	0.11	0	1
D_vacant	0	0	0	0
D_MillsAct	0.00076	0.03	0	1
D_garage	0.82	0.38	0	1
DIST_Shop	0.51	0.28	0	1.59
DIST_ES	0.31	0.20	0	1.17
DIST_parks	0.54	0.34	0	1.49
DIST_golf	1.59	0.59	0	2.95
SD_100	26.33	20.01	0	82.37
D_highway	0.023	0.15	0	1

Table 22 Descriptive Statistics of Properties sold in 2010-2011

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.81	0.34	11.32	13.95
VALUE	390504	145817	82852	1139210
DIST_NP	1.97	1.18	0	4.57
DIST_OW	1.54	0.72	0	3.26
VIEW_NP	0.58	0.49	0	1
VIEW_OW	0.39	0.49	0	1
SQFT	1536.98	640.43	520	5576
LOTSIZE	8171.84	4176.92	1520	29733
NBR_BATH	1.83	0.82	1	7
NBR_BEDRMS	2.99	0.80	1	7
AGE	61.64	14.55	2	121
D_pool	0.17	0.38	0	1
D_spa	0.0065	0.08	0	1
D_vacant	0.0014	0.04	0	1
D_MillsAct	0	0	0	0
D_garage	0.84	0.37	0	1
DIST_Shop	0.51	0.29	0	1.75
DIST_ES	0.32	0.20	0	1.21
DIST_parks	0.52	0.33	0	1.41
DIST_golf	1.61	0.59	0	3.06
SD_100	26.86	19.28	0	82.37
D_highway	0.021	0.14	0	1.0

Table 23 Descriptive Statistics of Properties sold in 2012-2013

Variable	Mean	Std. Dev.	Min	Max
ln_VALUE	12.84	0.34	11.29	13.85
VALUE	401201	146016	80000	1034941
DIST_NP	2.00	1.16	0	4.46
DIST_OW	1.47	0.72	0	3.29
VIEW_NP	0.57	0.50	0	1
VIEW_OW	0.39	0.49	0	1
SQFT	1551.07	615.20	601	5863
LOTSIZE	8448.98	4315.28	1607	29556
NBR_BATH	1.84	0.77	1	6
NBR_BEDRMS	2.96	0.80	1	8
AGE	63.62	13.29	5	128
D_pool	0.16	0.37	0	1
D_spa	0.01	0.12	0	1
D_vacant	0.00076	0.03	0	1
D_MillsAct	0.0015	0.04	0	1
D_garage	0.86	0.35	0	1
DIST_Shop	0.51	0.29	0	1.75
DIST_ES	0.32	0.21	0	1.20
DIST_parks	0.49	0.31	0	1.42
DIST_golf	1.53	0.60	0	3.07
SD_100	24.96	19.30	0	82.37
D_highway	0.015	0.12	0	1

The average price of single family houses remained around $30,000 in 1990s. There was no significant increase or decrease in the decade. Starting from 2000, it rapidly increased and reached $631,174 in 2005 and 2006. Since 2006, the average price decreased to $401,201 in eight years.

5.8 Standardizing Value over Time

Even though transaction sales price can be adjusted by the Consumer's Price Index for the whole data over 28 years, it does not fully explain the magnitude of changes in economic status and structure on the sales price. The measure surely helps adjust for macroeconomic, regional, and local factors affecting property values or even shifting the baseline of outcomes, but not perfectly. However, considering the meaning of hedonic price models, the major goal of a hedonic study is to estimate effect of an amenity on property values of near area by its 'proximity' or 'view' or 'composition of open spaces. The method cannot capture overall impact an amenity may have on the economy or the region. It is not about actual increase of value, but it is about examining the association an amenity has on values of approximate properties. When the percentage of the increase associated with proximity or view becomes the impact of the interest, the comparison can be much easier. In this regard, this study reveals the percentage increase associated with proximity between each period of time by using Log-Linear models. In addition, standardized coefficients are calculated and used to compare among each period.

5.9 Model Choice

Following set of methods will be applied for entire study period, 1986 to 2013, to construct a standard model specification. This standard model specification will then be employed for the subsets of data, 2-year periods.

Firstly, regressions were performed on the dependent and independent variables confirmed. To start with, only structural and time variables were entered into the hedonic equation. The result was examined and the level of influence for each variable was revealed. Log linear models were conducted and other models were tested. Fixed-effects models were introduced to account for potentially omitted variables, and potentially unaccounted externalities. Temporal scale dummy variables were included to capture the effects of unobserved factors that are constant or similar as the fixed effect. For instance, if the value of homes in a particular area is especially high because of some unobservable factor, then the fixed effects can be applied for the zone they belong. Similarly, unexpected events that occurred in the period of time can be accounted by the dummy variable that compares with other periods of time (Bui & Mayer, 2003; Heintzelman & Tuttle, 2012; Pope, 2008; Redfearn, 2009). In addition to the fixed effects models, the presence of spatial dependence effects among property values was examined and confirmed by Moran's I test. Spatial econometric techniques such as spatial-lag, spatial-error, and spatial autoregressive models were adopted to the model (Kelejian & Prucha, 1998)(Saphores & Li, 2011).

5.10 Regression Diagnostics

Outlier, normality, linearity, and homoscedasticity issues are discussed in the following sections.

5.10.1 Outlier

Upon the completion of data gathering and processing, the data set was examined for outliers. Extreme outliers were detected and removed using standard deviation, residuals, and sales price. To begin with, 703 cases more than three standard deviations from the mean value of the dependent variable were removed. Also, 463 cases with sales prices after adjustment below $75,000 were removed and 1,230 cases with missing values were removed. By visually examining the residual plot, 33 cases with outlying/extreme residuals were removed. As a result, 2,726 cases are removed from the original 25,562 sales transactions of single family houses.

5.10.2 Normality

Multiple regression models require normal distribution of variables, especially dependent variable. Normality is one of basic assumptions of multiple regression models. The residuals, from regressions with non-normal distribution of variables, produce statistically problematic Z-tests and other test scores that assume the normal distribution, such as t-tests, F-tests and chi-squared tests. Also, wrong functional form or missing variables results in the residuals of non-normal distribution. Further measures like correcting functional form and adjusting variables may produce residuals that are normally distributed.

According to Tabachnick and Fidell (2001), when the error term has equal variance and is independent across observations, it is acceptable not to further treat and remove individual variables for normality. As Figure 6 shows, residuals from a standard hedonic model appear to be approximately normally distributed.

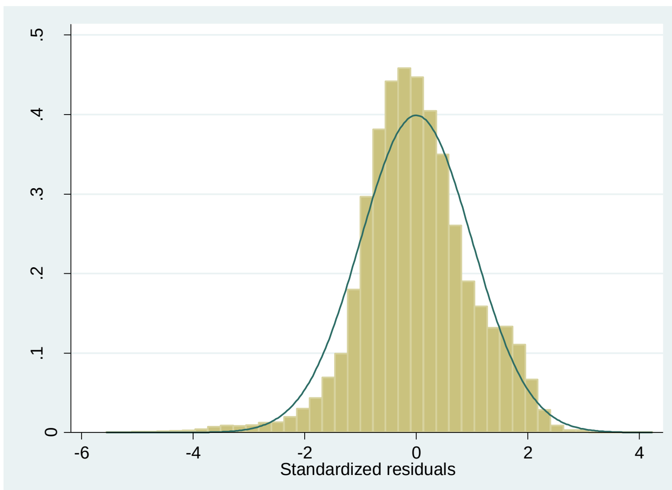


Figure 6 Histogram of residuals of sales price logged

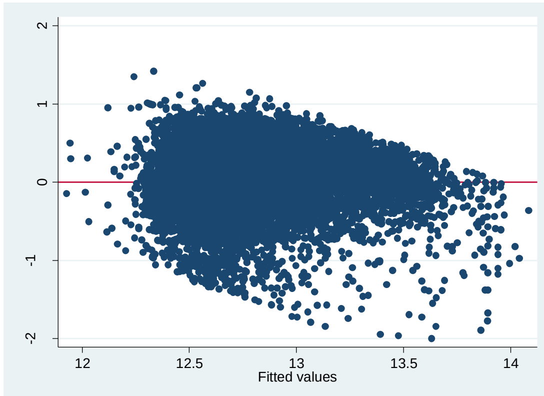
Table 24 Skewness/Kurtosis tests for Normality of the residual

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
e	2.00E+04	0.0000	0.0000	.	0.0000

5.10.3 Homoscedasticity

Homoscedasticity means that the error variance is constant across all values and combination of values of the independent variables. While homoscedasticity and heteroscedasticity issues are not critical model bias, they are more related to impact significance testing, confidence intervals, and estimation of the standard errors of the estimates (J.M. Wooldridge, 2009).

Homoscedasticity is visually examined from residuals plots. With the initial variable choice and model specification, the plotting of residuals versus fitted value appeared potentially problematic. As shown in figure 7, the residual scatterplot is divergent or convergent fan shape, which suggests heteroscedasticity of the model. After re-examining through variables that have non-normal distribution, usually skewed in one direction due to scaling issues, were logged. Figure 9, 10, 11, and 12 show histograms of living area and lot size before and after their conversion. Distribution of those variables became more close to a normal distribution. After the conversion of the two variables, residuals are more evenly distributed and symmetrically patterned like a cloud of points, which indicates homoscedasticity.



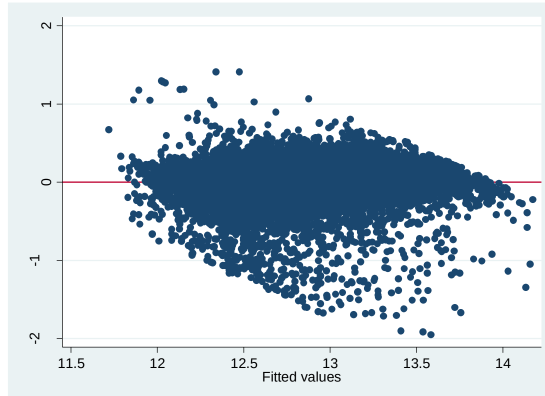


Figure 7 Scatterplot of residual vs Predicted value before adjustment

Figure 8 Scatterplot of residual vs Predicted value after adjustment

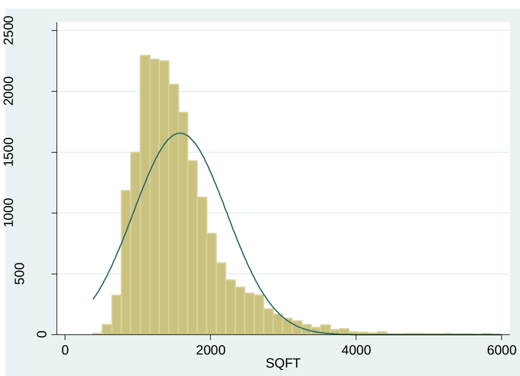


Figure 9 Histogram of living area

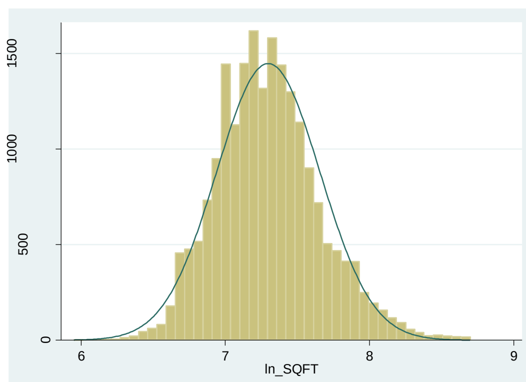


Figure 10 Histogram of living area logged

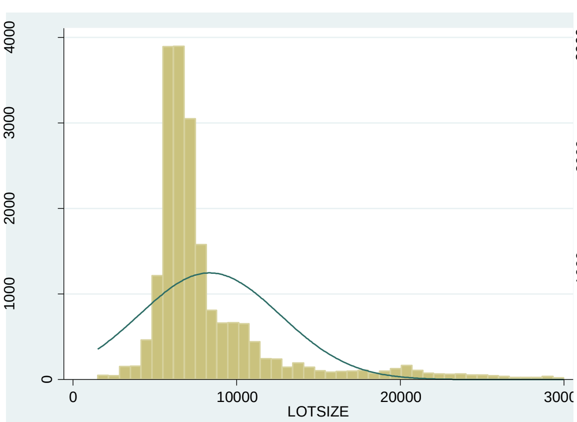


Figure 11 Histogram of lot size

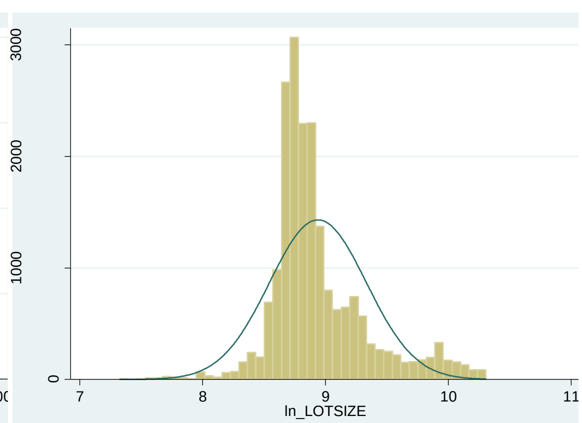


Figure 12 Histogram of lot size logged

5.10.4 Spatially Autocorrelation

The consequences of spatially autocorrelated errors include biased and inconsistent coefficients measures, intercept term, variance of error terms, and estimator of the standard error (Bowen et al., 2001; McConnell & Walls, 2005). To deal with spatial autocorrelation, spatial hedonic modelling is introduced. Among spatial modelling techniques, spatial-autoregressive model with spatial autoregressive residuals (SAC) is employed to take care of spatial autocorrelation for accurate comparison of the models. The Moran'I, confirmed the existence of spatial dependency and the LM and LR test specified the use of SAC for the spatial econometrics.

5.10.5 Multicollinearity

Multicollinearity is caused by highly correlated independent variables included in the hedonic price model. Overall explanation of the model (R^2) or predicting the dependent variable may not be significantly affected by multicollinearity, since highly correlated variables substantially consist of the same information. However, influences for each individual variable to the dependent variable may not be accurately measured because the influences can be attributed to other correlated independent variables (J.M. Wooldridge, 2009). In the study, multicollinearity was tested by several measures. First, any correlations that exceed ± 0.7 on a correlation matrix were carefully examined. Second, variance inflation factors, VIF, tests were conducted for every hedonic model. VIF over ten were assumed for multicollinearity. Last, tolerance values for each model were calculated. The low tolerance value, which ranges from 1 to 0, means high degree of collinearity (Loomis & Walsh, 1997; J.M. Wooldridge, 2009).

5.11 Model Specification

Regression diagnostics revealed issues regarding the form of variables, which may cause issues of heteroscedasticity in the model. As the measure to deal with the issue, logs were taken for the house size and lot size variables. After the conversion, the regression model faced the issue of over specifying the model. As shown in Table 25, number of bathrooms and bedrooms were significant at level of 0.89 and 0.56, respectively. To take measures on the issue, several model specifications were tested. Table 25, 26, 27, and 28 present regression models with the different sets of structural variables.

The model 1, which consists of all the structural variables, has an R^2 of 0.71 and siginificant coefficients throughout the model except for the number of bathrooms and bedrooms, and view of oil well sites. The number of bathrooms and bedrooms are not significant statistically. The model 2, which excluded lot size, has a R^2 of 0.69. The model produced all significant coefficients except for number of bathrooms. The model 3 substituted the house size with the lot size. It has R^2 of 0.69 and all the structural variables statistically significant. The only variable in the model 3 not significant is the view of the oil well sites. Lastly, model 4 has included both the house size and lot size variables and excluded the number of bathrooms and bedrooms variables. The R^2 for the model is 0.71 with the highest F value of 1133. The model was the most parsimonious and produced the best R^2 and F values.

By comparing the model alternatives, the role of each structural variable of the dataset became clearer in the model. The size of living area may already represent other structural variables like the number of bathrooms and bedrooms. In this study, it is statistically more valid to include the size of house and the size of lot and to exclude the number of bathrooms and the number of bedrooms variables in the final model.

Table 25 Regression Model alt1 (R^2= 0.7102, and F = 1083 with Prob > F = 0)

Model 1	**Coef.**	**Std. Err.**	**t**	**P>t**
DIST_NP	-0.024	0.0018	-13.2	0.00
DIST_OW	-0.023	0.0029	-7.75	0.00
VIEW_NP_INT	0.002	0.00027	9.33	0.00
VIEW_OW_INT	-0.00034	0.00030	-1.15	0.25
ln_SQFT	*0.36*	*0.010*	*36.77*	***0.00***
ln_LOTSIZE	*0.208*	*0.0063*	*33.2*	***0.00***
NBR_BATH	*0.00052*	*0.0036*	*0.14*	***0.89***
NBR_BEDRMS	*-0.0016*	*0.0028*	*-0.58*	***0.56***
AGE	-0.00047	0.00015	-3.19	0.001
D_pool	0.058	0.0046	12.75	0.00
D_spa	0.061	0.016	3.72	0.00
D_MillsAct	0.21	0.041	5.1	0.00
D_garage	0.023	0.0051	4.88	0.00
DIST_Shop	0.063	0.0072	8.75	0.00
DIST_ES	-0.054	0.010	-5.35	0.00
DIST_Park	-0.045	0.0063	-7.2	0.00
DIST_golf	-0.14	0.0047	-30.44	0.00
SD_100	0.0011	0.00011	10.23	0.00
D_highway	-0.075	0.013	-5.71	0.00

Table 26 Regression Model alt2 (R^2= 0.6945, and F = 1027 with Prob > F = 0)

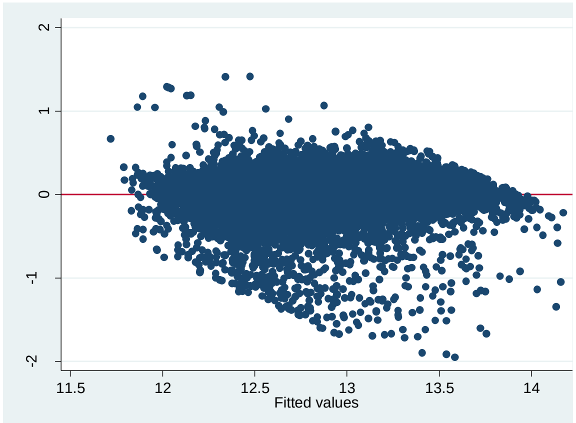
Model 2	**Coef.**	**Std. Err.**	**t**	**P>t**
DIST_NP	-0.029	0.0018	-16.14	0.00
DIST_OW	-0.037	0.0029	-12.46	0.00
VIEW_NP_INT	0.0029	0.00027	10.43	0.00
VIEW_OW_INT	-0.0008	0.00030	-2.59	0.01
ln_SQFT	*0.476*	*0.0094*	*50.57*	***0.00***
NBR_BATH	*-0.00088*	*0.0037*	*-0.24*	***0.81***
NBR_BEDRMS	*-0.010*	*0.0028*	*-3.5300*	***0.00***
AGE	-0.00043	0.00015	-2.82	0.01
D_pool	0.079	0.0047	17	0.00
D_spa	0.057	0.017	3.37	0.00
D_MillsAct	0.235	0.042	5.63	0.00
D_garage	0.024	0.0049	4.82	0.00
DIST_Shop	0.10	0.0073	14.3	0.00
DIST_ES	-0.058	0.010	-5.63	0.00
DIST_Park	-0.012	0.0064	-1.94	0.05
DIST_golf	-0.19	0.0047	-39.88	0.00
SD_100	0.0014	0.00011	12.19	0.00
D_highway	-0.101	0.013	-7.5	0.00

Table 27 Regression Model alt3 (R^2= 0.6908, and F = 989 with Prob > F = 0)

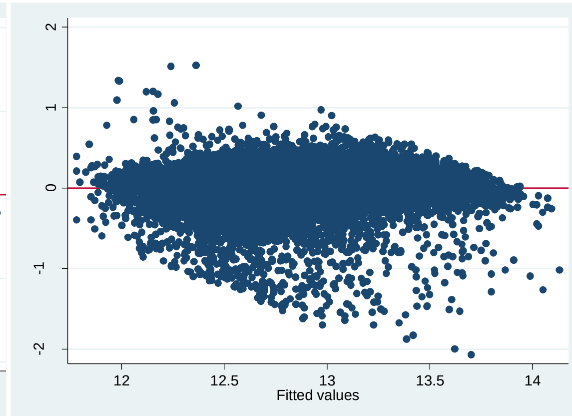
Model 3	**Coef.**	**Std. Err.**	**t**	**P>t**
DIST_NP	-0.037	0.0018	-20.22	0.00
DIST_OW	-0.022	0.0030	-7.5	0.00
VIEW_NP_INT	0.0027	0.00028	9.97	0.00
VIEW_OW_INT	-0.00032	0.00031	-1.04	0.30
ln_LOTSIZE	*0.29*	*0.0060*	*47.78*	***0.00***
NBR_BEDRMS	*0.039*	*0.0026*	*14.79*	***0.00***
NBR_BATH	*0.074*	*0.0031*	*23.43*	***0.00***
AGE	-0.00105	0.00015	-6.94	0.00
D_pool	0.065	0.0047	13.73	0.00
D_spa	0.082	0.017	4.87	0.00
D_MillsAct	0.28	0.042	6.75	0.00
D_garage	0.017	0.0049	3.52	0.00
DIST_Shop	0.077	0.0074	10.38	0.00
DIST_ES	-0.064	0.010	-6.09	0.00
DIST_Park	-0.068	0.0065	-10.46	0.00
DIST_golf	-0.16	0.0048	-33.46	0.00
SD_100	0.0015	0.00011	13.16	0.00
D_highway	-0.089	0.014	-6.59	0.00

Table 28 Regression Model alt4 (R^2= 0.7102, and F = 1133 with Prob > F = 0)

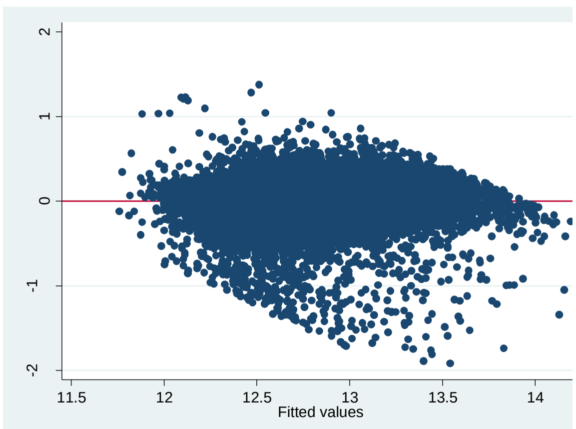
Model 4	**Coef.**	**Std. Err.**	**Beta**	**t**	**P>t**
DIST_NP	-0.024	0.0017	-0.065	-13.58	0.00
DIST_OW	-0.023	0.0029	-0.038	-7.76	0.00
VIEW_NP_INT	0.0025	0.00027	0.037	9.32	0.00
VIEW_OW_INT	0.00034	0.00030	-0.0046	-1.14	0.26
ln_SQFT	*0.36*	*0.0067*	*0.297*	*53.23*	***0.00***
ln_LOTSIZE	*0.21*	*0.0062*	*0.189*	*33.40*	***0.00***
AGE	-0.00047	0.00015	-0.017	-3.26	0.00
D_pool	0.058	0.0046	0.053	12.76	0.00
D_spa	0.061	0.016	0.014	3.73	0.00
D_MillsAct	0.207	0.041	0.019	5.09	0.00
D_garage	0.023	0.0048	0.019	4.87	0.00
DIST_Shop	0.063	0.007	0.041	8.75	0.00
DIST_ES	-0.054	0.010	-0.026	-5.37	0.00
DIST_Park	-0.045	0.0063	-0.033	-7.20	0.00
DIST_golf	-0.144	0.0047	-0.196	-30.72	0.00
SD_100	0.0011	0.00011	0.052	10.38	0.00
D_highway	-0.075	0.013	-0.025	-5.74	0.00



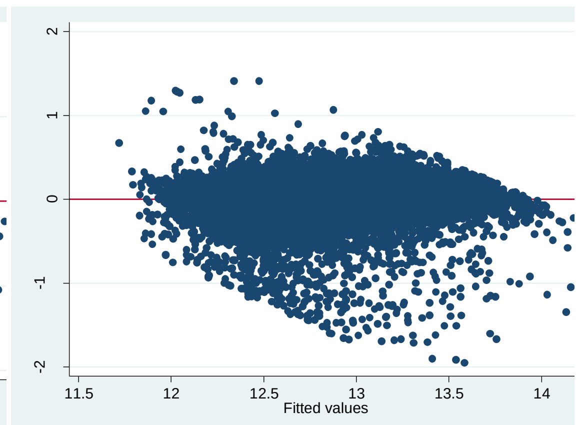
R^2= 0.7102 and F = 1083



R^2= 0.6945 and F = 1027



R^2= 0.6908 and F = 989



R^2= 0.7102 and F = 1133

Figure 13 Comparison of scatterplot of residual (Model1, 2, 3, and 4)

CHAPTER VI

ANALYSES AND RESULTS I: STANDARD MODEL BEFORE AND AFTER

6.1 Regressions for Entire Years in a Period

The standard model consists of structural, locational, and neighborhood dependent variables. Based on variable selection in chapter 4.5 and model specification and diagnostics in chapter 5, the following variables are selected for the standard hedonic pricing model: distance to the nature preserve, distance to the oil well site, view of the nature preserve, view of the oil well, house size logged, lot size logged, age of house, existence of pool, existence of spa, existence of garage, enrollment in Mills Act program, highway within 1/4 mile, year of sale dummies, distance to the nearest shopping mall, elementary school, park, and golf course, and land use diversity index.

A regression was run with these seventeen independent variables and twenty seven year dummy variables. Results are listed in Table 29. The model was highly significant (F = 1133, significance= 0.00) with an R^2 of 0.71. According to the standardized coefficients and levels of significance, the most influential factors on sales prices in the area over 28 years were house and lot size; distance to golf courses, and distance to nature preserve. One percent increase in square foot of house and lot size are associated with 0.36% and 0.21% increase in the sales price, respectively and all significance at 0.00 in both cases. Each additional mile close to golf course yields 14.4% increase in the value of the property.

For other structural variables, existence of pool, spa, and/or garage increase value of single family homes. Pool adds 5.8% premium to the value of the property. Likewise, each spa and garage increases the value of property by 6.1% and 2.3%, respectively. In addition to the physical features of the property, enrollment in Mills Act program, participating in the restoration and maintenance of qualified historic properties, increases the value of property by 20.7%. Properties in the Mills Act Program are valued more for its aesthetic quality, historical value, quality maintenance, and tax benefits. However, in general, age of house is negatively associated with the value of the property. Getting a year older decreases the value of the single family house by 0.047%. All above coefficients are statistically significant at 0.00 in the study period of 28 years as a whole.

Table 29 Regression all years

Variable	**Unstandardized Coefficients**		**Standardized Coefficient**	**t**	**P>t**	**VIF**	**Tolerance**
	Coef.	**Std. Err.**	**Beta**				
DIST_NP	-0.024	0.002	-0.065	-13.58	0.00	1.60	0.62
DIST_OW	-0.023	0.0029	-0.038	-7.76	0.00	1.72	0.58
VIEW_NP_INT	0.002	0.00027	0.037	9.32	0.00	1.12	0.89
VIEW_OW_INT	0.000	0.00030	-0.0046	-1.14	0.26	1.16	0.86
ln_SQFT	0.359	0.007	0.297	53.23	0.00	2.18	0.46
ln_LOTSIZE	0.208	0.006	0.189	33.40	0.00	2.24	0.45
AGE	-0.00047	0.00015	-0.017	-3.26	0.00	2.01	0.50
D_pool	0.058	0.005	0.053	12.76	0.00	1.19	0.84
D_spa	0.061	0.016	0.014	3.73	0.00	1.01	0.99
D_MillsAct	0.207	0.041	0.019	5.09	0.00	1.02	0.98
D_garage	0.023	0.005	0.019	4.87	0.00	1.06	0.94
DIST_Shop	0.063	0.007	0.041	8.75	0.00	1.57	0.64
DIST_ES	-0.054	0.010	-0.026	-5.37	0.00	1.59	0.63
DIST_Park	-0.045	0.006	-0.033	-7.20	0.00	1.44	0.69
DIST_golf	-0.144	0.0047	-0.196	-30.72	0.00	2.84	0.35

Table 29 continued

Variable	Unstandardized Coefficients		Standardized Coefficient	t	P>t	VIF	Tolerance
	Coef.	Std. Err.	Beta				
D_highway	-0.075	0.013	-0.025	-5.74	0.00	1.31	0.77
SD_100	0.001	0.00011	0.052	10.38	0.00	1.75	0.57
YD_1986	-0.246	0.019	-0.056	-13.18	0.00	1.25	0.80
YD_1987	-0.189	0.022	-0.035	-8.51	0.00	1.16	0.86
YD_1988	-0.146	0.011	-0.071	-12.88	0.00	2.13	0.47
YD_1989	-0.003	0.012	-0.0013	-0.25	0.81	2.00	0.50
YD_1990	0.024	0.013	0.010	1.92	0.06	1.74	0.57
YD_1991	-0.002	0.012	-0.0008	-0.15	0.88	1.73	0.58
YD_1992	-0.058	0.013	-0.022	-4.49	0.00	1.67	0.60
YD_1993	-0.165	0.012	-0.069	-13.63	0.00	1.80	0.56
YD_1994	-0.218	0.011	-0.102	-19.18	0.00	1.99	0.50
YD_1995	-0.257	0.012	-0.110	-21.57	0.00	1.82	0.55
YD_1996	-0.322	0.012	-0.144	-27.72	0.00	1.89	0.53
YD_1997	-0.326	0.011	-0.152	-28.68	0.00	1.96	0.51
YD_1998	-0.277	0.011	-0.132	-24.65	0.00	2.01	0.50
YD_1999	-0.214	0.011	-0.103	-19.19	0.00	2.03	0.49
YD_2000	-0.156	0.011	-0.072	-13.73	0.00	1.95	0.51
YD_2001	-0.080	0.011	-0.039	-7.20	0.00	2.05	0.49
YD_2002	0.058	0.011	0.027	5.12	0.00	1.96	0.51
YD_2003	0.216	0.011	0.101	19.11	0.00	1.95	0.51
YD_2004	0.437	0.011	0.202	38.50	0.00	1.94	0.52
YD_2005	0.612	0.012	0.266	52.13	0.00	1.83	0.55
YD_2006	0.663	0.012	0.263	53.60	0.00	1.69	0.59
YD_2007	0.571	0.013	0.203	43.08	0.00	1.55	0.64
YD_2008	0.287	0.012	0.113	23.11	0.00	1.69	0.59
YD_2009	0.155	0.012	0.065	12.95	0.00	1.78	0.56
YD_2010	0.152	0.012	0.062	12.47	0.00	1.74	0.57
YD_2011	0.074	0.012	0.031	6.17	0.00	1.79	0.56
YD_2012	0.070	0.012	0.030	5.89	0.00	1.82	0.55
_cons	8.529	0.063	.	136.33	0.00		

The locational variables in the regression model are distance to shopping, elementary schools, parks, and golf courses. As previous literature reveals, elementary schools, parks, and golf courses are amenities that add premium to single family residential properties. The premium for being close to the golf course was the highest among the three variables. Location one mile closer to golf course increases the property value by 14.4%, significance= 0.00. For elementary schools and parks, single family homes yield 5.4% and 4.5% increase as the property gets a mile closer, respectively. On the other hand, shopping malls had negative impact on the value of the properties. Value of single family homes increased by 6.3% as they were located a mile further away from the shopping malls. All the coefficients were statistically significant at 0.00 level.

Land use diversity has a positive impact, in general for 28 years, on the value of single family residential properties. When the land use of a neighborhood is completely diverse, meaning each land use share exact same amount of land in the boundary, properties in the neighborhood has 11% premium compared to properties in a neighborhood with only one dominating land use. Single family homes located within 1/4 mile of the major highway loses 7.5% of its value compared to the properties outside the boundary, holding other conditions constant.

Lastly, the independent variables of the study, both the distance to nature preserve and oil well sites, showed positive associations for the period of the entire years. The single family house was valued 2.4% higher when the property was one mile close to the nature preserve, holding other factors constant. Similarly, location of one mile closer to the oil wells yielded 2.3% premium on the property. However, the dataset of this model included all the transaction data for entire study period. The period includes times before and after the conversion of the oil well site to a nature preserve. Hence, the impact of oil wells is the combined impact of those two phases. This will be further examined in the following section.

6.2 Regressions Before and After the Conversion

As above regression presented mixed results for the independent variables, the distance to nature preserve and oil well site, further regression estimation were conducted for two periods, before and after the conversion. The first period, before the conversion, consists of sales transactions that took place in 8 years from 1986 to 1993. The second period, after the conversion, takes sale transaction data in 20 years from 1994 to 2013. Two regressions were run with same seventeen independent variables and different year dummy variables. Results are listed in Table 30 and Table 31. Both models were significant with an R^2 of 0.52 and 0.78, and F of 202 and 1472, respectively.

6.2.1 Regression Before the Conversion

According to the standardized coefficients and levels of significance, the most influential factors on sales prices in the area in 8 years before the conversion were house and lot size; distance to golf courses, and distance to nature preserve. One percent increase in square foot of house and lot size are associated with 0.30% and 0.24%

increase in the sales price, respectively and all significance at 0.00 in both cases. Each additional mile close to golf course yields 15% increase in the value of the property. Distance to oil wells was the only variable that was not statistically significant. The variable had t value of -1.15 and significance level of 0.25.

For other structural variables, existence of pool, spa, and/or garage have positive impact on value of single family homes. Existence of a pool increases the value of the property by 6.8%. Likewise, each spa and garage adds premium to the value of property by 11% and 6.1%, respectively. In addition to the physical features of the property, enrollment in Mills Act program increases the value of property by 21%. However, in general, age of house is negatively associated with the value of the property. Getting a year older decreases the value of the single family house by 0.012%. All above coefficients are statistically significant at 0.00 in the study period of 8 years.

Among the locational variables, elementary school, park, and golf course are amenities that add premium to single family residential properties. Similar to the result of the regression for all years, the premium for being close to the golf course was the highest among the three variables. A property located one mile closer to golf course increases the property value by 15%, significance= 0.00, holding other factors constant. For elementary school and park, single family homes yield 5.3% and 6.4% increase as the property gets a mile closer, respectively. On the other hand, location near a shopping mall decreases the value of a single family home by 4.9% per mile. All the coefficients were statistically significant at 0.00 level.

Table 30 Regression before the conversion (R^2= 0.52)

ln_VALUE	Unstandardized Coefficients		Standardized Coefficient	t	P>t	VIF	Tolerance
	Coef.	Std. Err.	Beta				
DIST_NP	-0.027	0.0038	-0.082	-7.04	0.000	1.58	0.63
DIST_OW	-0.0077	0.0064	-0.014	-1.18	0.236	1.76	0.57
VIEW_NP_INT	0.0025	0.00053	0.045	4.62	0.000	1.13	0.88
VIEW_OW_INT	-0.0016	0.00062	-0.021	-2.49	0.013	1.17	0.86
ln_SQFT	0.30	0.015	0.28	20.16	0.000	2.2	0.46
ln_LOTSIZE	0.24	0.013	0.25	17.98	0.000	2.23	0.45
AGE	-0.0012	0.00035	-0.041	-3.36	0.001	1.78	0.56
D_pool	0.068	0.010	0.069	6.9	0.000	1.19	0.84
D_spa	0.11	0.033	0.030	3.18	0.001	1.01	0.99
D_MillsAct	0.21	0.078	0.025	2.65	0.008	1.03	0.97
D_garage	0.061	0.012	0.048	5.06	0.000	1.05	0.95
DIST_Shop	0.049	0.016	0.036	3.08	0.002	1.59	0.63
DIST_ES	-0.053	0.022	-0.028	-2.38	0.017	1.61	0.62
DIST_Park	-0.064	0.014	-0.051	-4.58	0.000	1.45	0.69
DIST_golf	-0.15	0.010	-0.23	-14.83	0.000	2.93	0.34
SD_100	0.0012	0.00025	0.059	4.79	0.000	1.78	0.56
D_highway	-0.060	0.028	-0.022	-2.1	0.036	1.31	0.77
YD_1986	0.009	0.021	0.0043	0.43	0.665	1.15	0.87
YD_1987	0.066	0.026	0.025	2.58	0.010	1.1	0.91
YD_1988	0.11	0.012	0.11	9.16	0.000	1.58	0.63
YD_1989	0.26	0.013	0.23	20.23	0.000	1.51	0.66
YD_1990	0.28	0.014	0.22	20.41	0.000	1.4	0.71
YD_1991	0.26	0.014	0.20	18.8	0.000	1.39	0.72
YD_1992	0.20	0.014	0.15	14.36	0.000	1.36	0.73
YD_1993	0.098	0.013	0.081	7.32	0.000	1.43	0.70
_cons	8.43	0.14	.	61.91	0.000		

Land use diversity has a positive impact, in general previous 8 years before the conversion, on the value of single family residential properties. When the land use of a neighborhood is completely diverse, properties in the neighborhood has 12% premium compared to properties in a neighborhood with only one dominating land use. Single family homes located within ¼ mile of the major highway decrease in value 6% compared to the properties beyond ¼ mile, holding other conditions constant.

The independent variables of the study, both the distance to nature preserve and oil well sites, showed positive associations for the period before the conversion like all years. However, the magnitude of the impact is significantly different. For the distance to nature preserve, single family house was valued 2.7% higher when the property was one mile closer to the nature preserve, holding other factors constant. For the distance to oil well sites, location of one mile closer to the oil wells only yielded 0.77% premium on the property. The view of nature preserve has a positive association to the value of the property whereas view of oil well site dampens that effect.

6.2.2 Regression After the Conversion

The most influential factors on sales prices in the area in 20 years after the conversion were house and lot size; and distance to golf courses according to the standardized coefficients and levels of significance. One percent increase in square foot of house and lot size are associated with 0.38% and 0.19% increase in the sales price, respectively and all significance at 0.00 in both cases. Distance to golf course was also associated with 13% increase in the value of the property by each additional mile close to the golf course. View of oil wells was the only variable that was not statistically significant. The variable had t value of 0.32 and significance level of 0.745.

Structural variables had similar coefficients as ones from the period before the conversion. Existence of pool, spa, and/or garage is positively associated with the value of single family homes. Existence of a pool yields 5.6% premium on the value of the property. Likewise, each spa and garage adds premium to the value of property by 3.9% and 1.9%, respectively. In addition to the physical features of the property, enrollment in Mills Act program increases the value of property by 25%. Age of house, on the other hand, is negatively associated with the value of the property. The value of the single family homes decreases by 0.17% as the house gets one year older. All above coefficients are statistically significant at 0.00 in the study period of 20 years after the conversion.

Similar to the result of the regression for 8 years before the conversion, the premium for being close to the golf course was the highest among the three variables. One mile proximity to golf course increases the property value by 13%, significance= 0.00, holding other factors constant. For elementary school and park, single family homes add 5.7% and 4.5% premium as the property gets a mile closer, respectively. On contrary, location near shopping mall decreases the value of single family homes by 6.4% for a mile closer to the shopping malls. All the coefficients were statistically significant at 0.00 level.

Table 31 Regression after the conversion (R^2= 0.78)

ln_VALUE	Unstandardized Coefficients		Standardized Coefficients	t	P>t	VIF	Tolerance
	Coef.	Std. Err.	Beta				
DIST_NP	-0.027	0.0018	-0.072	-14.8	0	1.62	0.62
DIST_OW	-0.030	0.0030	-0.050	-9.94	0	1.71	0.59
VIEW_NP_INT	0.0022	0.00029	0.030	7.48	0	1.12	0.89
VIEW_OW_INT	0.00010	0.00032	0.0013	0.32	0.745	1.16	0.87
ln_SQFT	0.38	0.0071	0.304	53.51	0	2.18	0.46
ln_LOTSIZE	0.19	0.0065	0.166	28.8	0	2.25	0.44
AGE	-0.0017	0.00015	-0.059	-11.21	0	1.84	0.54
D_pool	0.056	0.0048	0.049	11.65	0	1.19	0.84
D_spa	0.039	0.018	0.0085	2.19	0.029	1.01	0.99
D_MillsAct	0.25	0.045	0.022	5.59	0	1.02	0.98
D_garage	0.019	0.0048	0.015	3.88	0	1.07	0.94
DIST_Shop	0.064	0.0075	0.041	8.54	0	1.57	0.64
DIST_ES	-0.057	0.011	-0.026	-5.37	0	1.59	0.63
DIST_Park	-0.045	0.007	-0.032	-6.91	0	1.44	0.69
DIST_golf	-0.13	0.0049	-0.177	-27.36	0	2.82	0.35
SD_100	0.0013	0.00011	0.060	11.87	0	1.74	0.57
D_highway	-0.084	0.014	-0.027	-6.09	0	1.31	0.77
YD_1995	-0.46	0.012	-0.226	-39.35	0	2.24	0.45
YD_1996	-0.52	0.011	-0.270	-45.83	0	2.34	0.43
YD_1997	-0.53	0.011	-0.282	-46.91	0	2.44	0.41
YD_1998	-0.48	0.011	-0.262	-43.06	0	2.5	0.40
YD_1999	-0.41	0.011	-0.229	-37.49	0	2.53	0.39
YD_2000	-0.35	0.011	-0.189	-31.69	0	2.4	0.42
YD_2001	-0.28	0.011	-0.155	-25.28	0	2.55	0.39
YD_2002	-0.14	0.011	-0.073	-12.27	0	2.39	0.42
YD_2003	0.023	0.011	0.012	2.06	0.039	2.38	0.42
YD_2004	0.24	0.011	0.130	22.09	0	2.36	0.42
YD_2005	0.42	0.011	0.211	37.05	0	2.2	0.46
YD_2006	0.47	0.012	0.217	39.91	0	2	0.50

Table 31 continued

ln_VALUE	Unstandardized Coefficients		Standardized Coefficients	t	P>t	VIF	Tolerance
	Coef.	Std. Err.	Beta				
YD_2007	0.38	0.013	0.155	30.03	0	1.8	0.56
YD_2008	0.10	0.012	0.046	8.43	0	1.98	0.51
YD_2009	-0.031	0.012	-0.015	-2.68	0.007	2.1	0.48
YD_2010	-0.033	0.012	-0.016	-2.85	0.004	2.05	0.49
YD_2011	-0.11	0.011	-0.054	-9.61	0	2.1	0.48
YD_2012	-0.11	0.011	-0.055	-9.81	0	2.13	0.47
_cons	8.83	0.066	.	134.78	0		

In general, land use diversity has a positive impact for 20 years after the conversion on the value of single family residential properties. For properties that are located in a neighborhood where land use is completely diverse a 13% premium is given compared to the properties in a neighborhood with only one dominating land use. Single family homes located within 1/4 mile of the major highway decreases 8.4% of its value compared to the properties outside the boundary, holding other conditions constant.

Both the distance to nature preserve and oil well sites showed positive associations for the period after the conversion like the previous period. Single family house located one mile closer to the nature preserve was valued 2.7% higher, holding other factors constant. For the distance to oil well sites, location of one mile closer to the oil wells yielded 3.0% premium on the property. The view of nature preserve has a positive association to the value of the property whereas view of oil well site has a statistically insignificant coefficient.

6.2.3 Comparison between Before and After the Conversion

Most of the variables shared similar impact, direction and magnitude, in both before and after models. In both models, structural variables like pool, garage, and spa, had positive association with the value of the properties. Locational variables, distance to park, elementary school, and golf course, also had positive association with the sales value, the closer to the amenities led to the higher price of the properties. A neighborhood with more diversified land use had premium over a neighborhood with less land uses.

To compare the magnitude of those two coefficients under standardized variances among each model, standardized coefficients are presented in Table 32. The regression before the conversion provided significantly larger estimates on variables of distance to nature preserve (DIST_NP), view of nature preserve (VIEW_NP_INT), and existence of spa (D_spa) and garage (D_garage). The regression after the conversion, in contrast, indicated larger coefficients for distance to oil well site (DIST_OW). The largest absolute difference in coefficients, except for logged independent variables, was for the variable distance to golf course (DIST_golf), with a standardized coefficient of -0.23 before and conversion and -0.18 after the conversion.

Table 32 Comparison of regression results before and after

ln_VALUE	Before conversion (1986~1994)			After conversion (1995~2013)		
	Coef.	Beta	P>t	Coef.	Beta	P>t
DIST_NP	-0.027	-0.082	0.000	-0.027	-0.072	0.000
DIST_OW	-0.0077	-0.014	0.236	-0.030	-0.050	0.000

Table 32 continued

ln_VALUE	Before conversion (1986~1994)			After conversion (1995~2013)		
	Coef.	**Beta**	**P>t**	**Coef.**	**Beta**	**P>t**
VIEW_NP_INT	0.0025	0.045	0.000	0.0022	0.030	0.000
VIEW_OW_INT	-0.0016	-0.021	0.013	0.00010	0.0013	0.745
ln_SQFT	0.30	0.28	0.000	0.38	0.30	0.000
ln_LOTSIZE	0.24	0.25	0.000	0.19	0.17	0.000
AGE	-0.0012	-0.041	0.001	-0.0017	-0.059	0.000
D_pool	0.068	0.069	0.000	0.056	0.049	0.000
D_spa	0.11	0.030	0.001	0.039	0.0085	0.029
D_MillsAct	0.21	0.025	0.008	0.25	0.022	0.000
D_garage	0.061	0.048	0.000	0.019	0.015	0.000
DIST_Shop	0.049	0.036	0.002	0.064	0.041	0.000
DIST_ES	-0.053	-0.028	0.017	-0.057	-0.026	0.000
DIST_Park_LC	-0.064	-0.051	0.000	-0.045	-0.032	0.000
DIST_golf	-0.15	-0.23	0.000	-0.13	-0.177	0.000
SD_100	0.0012	0.059	0.000	0.0013	0.060	0.000
D_highway	-0.060	-0.022	0.036	-0.084	-0.027	0.000

As shown in Figure 14, generally nature preserve shows decrease and oil well site shows increase in positive association after the conversion. Standardized coefficients of distance to nature preserve slightly increased after the conversion of the neighboring site, meaning decrease in positive association to housing price. The positive association of proximity was -0.082 before the conversion and decreased -0.077 after the conversion. On the other hand, standardized coefficients of distance to oil wells site increased in positive association after the conversion. Before the conversion, positive impact of DIST_NP is almost 6 times stronger than the impact of DIST_OW. The coefficient of DIST_OW before the conversion is insignificant. After the conversion, the gap narrowed down to the ratio of -0.72 to -0.50. On average in twenty years, the impact of DIST_OW is close to the impact of nature preserve. This will be more closely examined at next chapter.

Figure 15 compares the coefficients of the view of nature preserve and oil well site before and after the conversion. It indicates the substantial effects of view of nature preserve from the properties. The coefficient of view of oil well site after the conversion is minimal and statistically not significant. The positive association of having a view to nature preserve decreased after the conversion whereas the view of oil well site has recovered its negative association to the value of single family houses. Before the conversion, having a view to oil well site had negative impact at the standardized coefficient at -0.021. It was not significantly different form zero after the conversion. The positive association of view of nature preserve has decrease from the coefficient of 0.45 to 0.30.

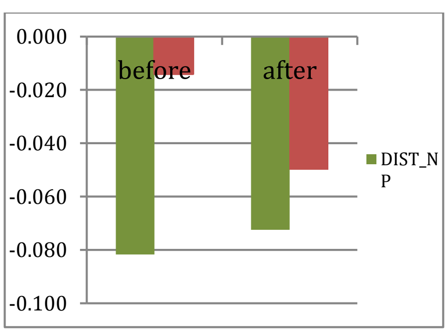


Figure 14 Standardized coefficients of distance to nature preserve and oil well

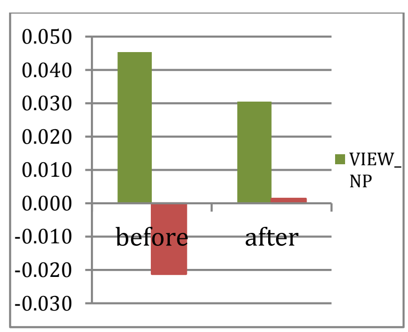


Figure 15 Standardized coefficients of view of nature preserve and oil well

CHAPTER VII

ANALYSES AND RESULTS II: SPATIAL HEDONIC MODEL

The dataset was divided into fourteen subsets of two year period data. Each subset of data was tested for spatial autocorrelation and spatial hedonic regressions were performed to account for spatial autocorrelation. Through several tests, including Moran's I, Geary's C, and Lagrange Multiplier tests, spatial-autoregressive models with spatial autoregressive residuals (SAC) are employed to account for spatial autocorrelation. Following sections present the results of log-linear models, log-linear models with standardized coefficients, and spatial hedonic models (SAC).

7.1 Log-linear Regressions in Two Year Periods

Table 33 presents results of the log-linear regressions in two year periods. The log-linear models were significant with R^2 ranging from 0.47 to. 0.73. As shown in Table 33, the most significant factors on sales prices in the area were house and lot size of the property. Both variables were significant at 0.01 level throughout the entire study period. They also showed consistent positive associations with the sale price of the single family houses. One percent increase in square foot of house was associated with a percentage increase ranging from 0.24% to 0.46% in the sales price. The positive association was high in 1986-1987 period, 0.43% increase per square foot, and the association dropped low in 1988-1989 period to 0.24%. After this sudden drop, the positive association gradually increased over 26 years reaching at 0.46% increase of sales price for one percent increase in square foot. Lot size, on the other hand, showed opposite trend of the square foot variable. In the early periods until 2003, the positive associations were above 0.2% reaching as high as 0.33% except for the period 1990-1991 and 1996-1997. In the period 2004-2005, the positive association dropped to 0.12% and remained around 0.16% for the rest of the period.

Age of the house was negatively associated with the sales price of the single family houses for the entire study period. The coefficients were significant except for the periods from 2002 to 2007. The negative association was relatively stronger in the years before 1997 ranging from -0.0020 to -0.0056. In the latter years, the coefficients were between -0.0014 and -0.0024. Closely related variable to age of the property is dummy variable for Mills Act program. Single family houses enrolled in Mills Act program benefits from taxes for their effort to keep the property in historically valuable conditions. While age of the house was negatively associated with the sales price, enrollment in Mills Act program increased the value of the property. The highest associated increase was 45.5% in the period 1988-1989. In the periods when the coefficients for Mills Act program were significant, the positive associations to the sales price were relatively stronger than other dummy variables like pools, garages, and spa. Enrollment in Mills Act program increased the sales price by as low as 27.7% to as high as 45.5%.

The structural dummy variables, existence of pool, spa, and garage, presented positive coefficients throughout the study period. While existence of pool had been significant for most of the study period except for 2 periods, 1986-1987 and 1992-1993, existence of spa and garage was not statistically significant in many periods. The existence of a pool in a single family house increased the sales price in the range of 3.7% to 11.6%. The positive association between pool and sales price was stronger before year 2002 and it settled around 5% for recent 12 years. Existence of spa was statistically significant in some periods before 2000. The highest increase for a spa was 14.1% in the period 1988-1989. In other periods when the coefficients were significant, the increase was around 10%. Existence of garage was associated with 18.7% increase in the sales price of single family houses in the period 1986-1987. In the following period 1988-1989, the positive association was 14.8% increase of the sales price and statistically significant. After these periods, there were 3 other periods when the positive associations were significant, periods 1998-1999, 2000-2001, and 2004-2005 with increase of 3.2%, 4.7%, and 4.7% respectively.

For locational variables, distance to elementary school, park, and golf course was negatively associated with the sales price of single family houses. Coefficients of distance to golf course were negative and statistically significant in all periods, which means being close to golf course had been a premium to the housing value. A location of one mile closer to golf course increases the property value by 7.2% to 17.5%. The coefficients do not show any trends of increasing or decreasing. The impact was consistent around 10% to 15% throughout the study period. Distance to park also presented negative coefficients within a certain range. Houses located one mile closer to the park had premium of 5.5% to 8.4% holding other factors constant. Except for the periods from 2002 to 2007 when the coefficients were not significant, parks had been stable in its positive effect on the value of single family houses. Distance to elementary school variable was not significant in many periods, however, when significant; it increased the value of near property. One mile closer to the elementary school increased the value of a single family home by 5.7% to 10.7%. On the other hand, distance to shopping mall had been positively associated with the value of properties. One mile closer to shopping mall is associated with 4.9% to 10.5% discount on the value of single family houses holding other factors constant. Like other locational variables, distance to elementary school and shopping mall did not show any trend of increasing or decreasing.

Diversity index had positive coefficients throughout the periods. One percent increase in diversity index of neighborhood is associated with 0.085% to 0.19% increase in the sales price of single family houses. More diverse the land use of neighborhood is more premium for the properties therein. In contrast, houses located within 1/4 mile of major highway had discount of 7.2% to 22.9%. These neighborhood variables did not show any trend of increasing or decreasing in their coefficients.

Distance to nature preserve had significant coefficients for the entire periods except for the period 2012-2013. It had negative association with the value of the property, premiums ranging from 1.5% to 4.6% of the sales price of single family houses on location of one mile closer to the nature preserve holding other factors constant. Before year 2000, the coefficients were below - 0.031 except for one period in 1988-1989. After year 2000, the coefficients had increased and they were above -0.029. This indicates that the positive impact of the nature preserve had decreased. On the other hand, the positive impact of former oil well site had increased. Before year 1996, coefficients for distance to oil wells were not significant. After year 1996, the negative association had been around 3% except for period 2008-2009 and 2012-2013. In the period 2008-2009, houses located one mile closer to the former oil well sites had premium of 4.2%, holding other factors constant, and in the period 2012-2013, the premium increased to 6.3%. The view of nature preserve had positive coefficients across the study period. In nine out of fourteen periods, coefficients were statistically significant. The coefficients ranged from 0.0019 to 0.0031 and did not show any trends. For the view of oil wells site, coefficients in four periods were statistically significant. Among the four, three of the coefficients are negative. The negative coefficients ranged from -0.0016 to -0.0033.

Table 33 Log-linear Regressions in two year periods

ln VALUE	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
R^2	0.675	0.527	0.553	0.512	0.559	0.685	0.691	0.714	0.634	0.559	0.471	0.647	0.690	0.728
DIST_NP	-0.034***	-0.022***	-0.046***	-0.035***	-0.033***	-0.045***	-0.031***	-0.026***	-0.029***	-0.018***	-0.015**	-0.025***	-0.029***	-0.0083
DIST_OW	-0.032	-0.008	-0.021*	0.00087	-0.012	-0.030***	-0.016*	-0.029***	-0.022**	-0.029***	-0.029**	-0.042***	-0.030***	-0.063***
VIEW_NP_INT	0.00082	0.0027***	0.0019*	0.0030***	0.0015	0.0027***	0.0010	0.0027***	0.0023***	0.0027***	0.0020	0.0015	0.0031***	0.0023**
VIEW_OW_IN	-0.0010	-0.0027**	-0.0033***	-0.00084	0.0012	0.0017**	-0.00069	-0.0016**	-0.0011	0.00073	-0.00034	0.00022	-0.00063	0.00053
ln_SQFT	0.433***	0.236***	0.353***	0.257***	0.311***	0.357***	0.349***	0.381***	0.385***	0.358***	0.361***	0.405***	0.421***	0.457***
ln_LOTSIZE	0.201***	0.325***	0.158***	0.283***	0.215***	0.184***	0.240***	0.222***	0.204***	0.122***	0.140***	0.174***	0.160***	0.162***
AGE	-0.0056***	-0.00021	-0.0039***	-0.0020***	-0.0035***	-0.004***	-0.0019***	-0.0015***	-0.00025	-0.00018	-0.00027	-0.0024***	-0.0023***	-0.0014***
D_pool	0.048	0.086***	0.116***	0.015	0.063***	0.056***	0.074***	0.071***	0.059***	0.059***	0.037**	0.037**	0.053***	0.052***
D_spa	0.015	0.141**	0.114*	0.114*	0.072	0.099	0.094**	-0.0077	0.051	0.012	-0.100	0.010	0.082	0.027
D_MillsAct	0.229	0.454***	0.134	0.313*	-0.081	0.436***	0.277***	0.304***	0.184	-0.139	0.134	0.244	0.000***	0.368***
D_garage	0.187***	0.148***	0.021	0.019	0.026	0.018	0.032**	0.047***	0.013	0.047***	-0.0023	0.021	-0.011	-0.016
DIST_Shop	0.064	0.049*	0.093***	0.0089	0.050*	0.055**	0.105***	0.075***	0.055**	0.041**	0.014	0.054**	0.089***	0.030
DIST_ES	-0.032	-0.063	-0.046	-0.038	-0.041	-0.080**	-0.036	-0.081***	-0.034	-0.057**	0.0068	-0.070*	-0.107***	-0.031
DIST_Park	-0.055	-0.054	-0.060**	-0.055**	-0.075***	-0.065***	-0.081***	-0.084***	0.0033	-0.0070	-0.039	-0.060***	-0.060***	-0.033*
DIST_golf	-0.075**	-0.175***	-0.152***	-0.136***	-0.120***	-0.145***	-0.151***	-0.156***	-0.139***	-0.106***	-0.080***	-0.139***	-0.154***	-0.072***
SD_100	0.0015*	0.0018***	0.0018***	0.00061	0.0011**	0.00085**	0.0018***	0.0019***	0.0012***	0.0012***	0.0017***	0.0014***	0.0014***	0.00017
D_highway	-0.229**	-0.013	-0.060	-0.087	-0.116**	-0.072*	-0.100**	-0.032	-0.118***	-0.053	-0.135***	-0.082*	-0.081**	0.024
YD_	0.071***	0.151***	-0.021	-0.105***	-0.039***	-0.0010	0.065***	0.079***	0.159***	0.169***	-0.096***	-0.130***	-0.078***	0.111***
_cons	7.762***	8.157***	9.200***	8.638***	8.722***	8.685***	8.085***	8.143***	8.409***	9.638***	9.681***	8.938***	8.842***	8.333***

*** significant at 0.01 level, ** significant at 0.05 level, * significant at 0.1 level

7.2 Spatial Regressions in Two Year Periods

7.2.1 Spatial Dependence Diagnostics

Spatial dependence was tested for each period using Moran's I and Geary's C test. Table 34 displays the diagnostics for spatial dependence obtained from the ordinary least squares model for each two year period. As shown in Table 34, all parameters of spatial autocorrelation indicate highly significant values for every period. According to the LM test for model selection, spatial-autoregressive model with spatial autoregressive residuals model (SAC) is used for the entire study period. Unifying model type into one single spatial model gives advantage to compare between coefficients. As the spatial hedonic models do not produce standardized coefficients, all explanatory variables were standardized and entered into the spatial regression in order to compare the magnitude of impacts. In addition, all the spatial autoregressive parameters, the sigma in the spatial-autoregressive model with spatial autoregressive residuals model, in all the SAC hedonic models are highly significant justifying the use of spatial models instead of the traditional log-linear models as seen in Table 33.

Table 34 Spatial Dependence Diagnostics

	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
GLOBAL Moran's I	0.046* (0)	0.056* (0)	0.054* (0)	0.079* (0)	0.074* (0)	0.075* (0)	0.090* (0)	0.147* (0)	0.119* (0)	0.080* (0)	0.098* (0)	0.088* (0)	0.082* (0)	0.030* (0)
GLOBAL Geary's C	0.902* (0.008)	0.897* (0)	0.914* (0)	0.877* (0)	0.910* (0)	0.882* (0)	0.893* (0)	0.816* (0)	0.849* (0)	0.857* (0)	0.864* (0)	0.904* (0)	0.944* (0.001)	0.942* (0.002)
LM Error	9.24. E+03* (0)	2.02. E+05* (0)	1.18. E+05* (0)	1.28. E+05* (0)	1.57. E+05* (0)	1.73. E+05* (0)	2.40. E+05* (0)	2.36. E+05* (0)	2.24. E+05* (0)	1.86. E+05* (0)	9.18. E+04* (0)	8.50. E+04* (0)	1.07. E+05* (0)	1.05. E+05* (0)
LM (Lag)	3.01 E+04* (0)	1.40 E+05* (0)	1.44 E+05* (0)	1.82 E+05* (0)	1.73 E+05* (0)	1.86 E+05* (0)	1.81 E+05* (0)	2.35 E+05* (0)	2.01 E+05* (0)	1.63 E+05* (0)	1.46 E+05* (0)	1.39 E+05* (0)	1.19 E+05* (0)	1.02 E+05* (0)
LM (SAC)	3.02 E+04* (0)	3.17 E+05* (0)	2.24 E+05* (0)	2.48 E+05* (0)	2.92 E+05* (0)	3.16 E+05* (0)	3.88 E+05* (0)	4.12 E+05* (0)	3.75 E+05* (0)	3.15 E+05* (0)	2.32 E+05* (0)	1.80 E+05* (0)	1.97 E+05* (0)	1.95 E+05* (0)

* significant at 0.01 level

7.2.2 SAC Models in Two Year Periods

The SAC models show similar or higher R^2 value and more significant coefficients for the entire fourteen study periods. As shown in Table 35, the most robust factors on sales prices in the area for the entire study periods were house and lot size. Both variables were significant at 0.01 level throughout the entire study period. They also showed consistent positive associations with the sale price of the single family houses. One percent increase in square foot of house was associated with a percentage increase ranging from 0.22% to 0.43% in the sales price. Like the log-linear models, the positive association was high in 1986-1987 period, 0.42% increase per square foot, and the association dropped low in 1988-1989 period to 0.22%. After this sudden drop, the positive association gradually increased over 26 years reaching at 0.43% increase of sales price for one percent increase in square foot. Lot size, on the other hand, showed opposite trend of the square foot variable. In the early periods until 2003, the positive associations were above 0.17% reaching as high as 0.30% except for the period 1990-1991. In the period 2004-2005, the positive association dropped to 0.11% and remained below 0.16% for the rest of the period.

Similar to log-linear models, age of the house was negatively associated with the sales price of the single family houses for the entire study period. The coefficients of SAC models were significant except for the periods from 2002 to 2007. The negative association was relatively stronger in the years before 1997 ranging from -0.0030 to -0.0054. In the latter years, the coefficients were between -0.0013 and -0.0026. Unlike age of house, which is negatively associated with the sales price, enrollment in Mills Act program increased the value of the property. The highest associated increase was 42.1% in the period 1988-1989. In the periods when the coefficients for Mills Act program were significant, the positive associations to the sales price were relatively stronger than other dummy variables like pools, garages, and spa. Enrollment in Mills Act program increased the sales price by as low as 24.2% to as high as 42.1%.

In the SAC models, the structural dummy variables, existence of pool, spa, and garage, presented positive coefficients throughout the study period. While existence of pool had been significant for most of the study period except for 2 periods, 1986-1987 and 1992-1993, existence of spa and garage were not statistically significant in many periods. The existence of a pool in a single family house increased the sales price in the range of 4.4% to 10.0%. The positive association between pool and sales price was stronger before year 2002 and it settled around 5% for recent 12 years. Existence of spa was statistically significant in some periods before 2000 and in period 2006-2007. The highest increase for a spa was 13.3% in the period 1988-1989. In other periods when the coefficients were significant, the increase was around 10% except for the period 2006-2007 when the effect was negative 11.0%. Existence of garage was associated with 19.4% increase in the sales price of single family houses in the period 1986-1987. In the following period 1988-1989, the positive association was 15.7% increase of the sales price and statistically significant. After these periods, there were 5 other periods when the positive associations were significant, periods 1994-1995, 1998-1999, 2000-2001, 2004-2005, and 2008-2009 with increase of 3.8%, 4.4%, 4.2%, 3.8% and 3.0% respectively.

For locational variables, distance to park and golf course was negatively associated with the sales price of single family houses and distance to elementary school was not significant for the most of the periods. Coefficients of distance to golf course were negative and statistically significant in all periods, which means being close to golf course had been a premium to the housing value. A location of one mile closer to golf course increases the property value by 4.9% to 16.0%. The coefficients do not show any trends of increasing or decreasing. The impact was consistent around 10% to 15% throughout the study period. Distance to park also presented negative coefficients within a certain range. Houses located one mile closer to the park had premium of 3.0% to 10.3% holding other factors constant. Except for the periods from 2002 to 2005 when the coefficients were not significant, parks had been stable in its positive effect on the value of single family houses. Distance to elementary school variable was significant in the period 2010-2011; and it increased the value of near property by 8.3% for one mile closer to the elementary school. Distance to shopping mall had coefficients statistically significant in two periods. In the period 1990-1991, one mile closer to shopping mall was associated with 5.3% discount on the value of single family houses holding other factors constant. In the period 2012-2013, being close to shopping mall was a premium and it added 4.8% of the sales price per one mile closer. Like other locational variables, distance to elementary school and shopping mall did not show any trend of increasing or decreasing.

Diversity index had positive coefficients throughout the periods. One percent increase in diversity index of neighborhood is associated with 0.066% to 0.12% increase in the sales price of single family houses. More diverse the land use of neighborhood is more premium for the properties therein. In contrast, houses located within 1/4 mile of major highway had discount of 7.7% to 24.8%. These neighborhood variables did not show any trend of increasing or decreasing in their coefficients.

Distance to nature preserve had significant coefficients for the entire periods except for the period 2012-2013. It had negative association with the value of the property, premiums ranging from 1.5% to 4.9% of the sales price of single family houses on location of one mile closer to the nature preserve holding other factors constant. Before year 2003, the coefficients were below - 0.033. After year 2003, the coefficients had increased and they were above -0.026. This indicates that the positive impact of the nature preserve had decreased. On the other hand, the positive impact of former oil well site had increased. Before year 2007, coefficients for distance to oil wells were around or higher than - 0.05. After year 1997, the negative association had increased period by period. In the period 2008-2009, houses located one mile closer to the former oil well sites had premium of 5.9%, holding other factors constant, and in the period 2010-2011, the premium increased to 7.3% and in the most recent period, the premium was at its highest, 9.5% increase of the sales price of single family houses. The view of nature preserve had positive coefficients across the study period. In nine out of fourteen periods, coefficients were statistically significant. The coefficients ranged from 0.0010 to 0.0025 and did not show any trends. The coefficients were not significant after year 2006. For the view of oil wells site, coefficients in four periods were statistically significant. Among the four, three of the coefficients are negative. The negative

Table 35 Spatial hedonic models (SAC) in two year periods

ln VALUE	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
R^2	0.674	0.522	0.580	0.493	0.616	0.722	0.716	0.713	0.633	0.532	0.474	0.673	0.694	0.752
DIST_NP	-0.042***	-0.033***	-0.053***	-0.044***	-0.040***	-0.049***	-0.039***	-0.033***	-0.039***	-0.025***	-0.015***	-0.024***	-0.026***	-0.008
DIST_OW	-0.044*	-0.032**	-0.045***	-0.026**	-0.053***	-0.053***	-0.058***	-0.049***	-0.043***	-0.039***	-0.049***	-0.059***	-0.073***	-0.095***
VIEW_NP_INT	0.0006	0.0025**	0.0018**	0.0020**	0.0010	0.0019**	0.0010*	0.0023***	0.0018***	0.0023***	0.0014	0.00036	0.0016	0.0012
VIEW_OW_IN	-0.0011	-0.0028***	-0.0034***	-0.0014	0.00067	0.0023***	-0.00083	-0.0018**	-0.0011	0.00058	0.0015	0.00032	-0.00062	0.00072
ln_SQFT	0.419***	0.219***	0.319***	0.231***	0.309***	0.339***	0.343***	0.358***	0.376***	0.342***	0.354***	0.382***	0.400***	0.429***
ln_LOTSIZE	0.178***	0.296***	0.111***	0.248***	0.179***	0.171***	0.201***	0.204***	0.185***	0.108***	0.124***	0.147***	0.133***	0.157***
AGE	-0.0054***	-0.000087	-0.0033***	-0.0030***	-0.0031***	-0.0032***	-0.0013***	-0.0019***	-0.00035	-0.00063	-0.00021	-0.0026***	-0.0023***	-0.0014***
D_pool	0.048	0.081***	0.100***	0.005	0.048***	0.061***	0.082***	0.074***	0.057***	0.058***	0.044***	0.048***	0.058***	0.045***
D_spa	0.014	0.133**	0.106**	0.106*	0.047	0.080	0.088**	-0.023	0.024	0.001	-0.110**	0.011	0.052	0.017
D_MillsAct	0.232	0.421***	0.088	0.288*	0.154	0.374***	0.242***	0.323***	0.149	-0.143	0.098	0.265	-	0.306***
D_garage	0.194***	0.157***	0.030	0.017	0.038**	0.020	0.044***	0.042***	0.019	0.038***	0.0094	0.030**	-0.0082	-0.016
DIST_Shop	0.044	-0.0007	0.053**	-0.029	-0.022	0.00050	0.033	0.0055	0.00488	0.00591	-0.017	-0.017	0.00726	-0.048**
DIST_ES	-0.018	-0.033	-0.043	-0.053	-0.055	-0.042	-0.015	-0.035	-0.028	-0.044	0.008	-0.026	-0.083**	-0.028
DIST_Park	-0.069	-0.052**	-0.052**	-0.069***	-0.052**	-0.071***	-0.087***	-0.103***	-0.023	-0.009	-0.044**	-0.040**	-0.030*	-0.047***
DIST_golf	-0.080**	-0.152***	-0.160***	-0.121***	-0.113***	-0.119***	-0.118***	-0.132***	-0.114***	-0.100***	-0.050***	-0.115***	-0.115***	-0.049***
SD_100	0.00087	0.00065	0.0012***	0.00011	0.00065	0.00032	0.00066**	0.0012***	0.00043	0.00088***	0.0011***	0.00079***	0.00091**	-0.0006*
D_highway	-0.248***	-0.035	-0.068	-0.122**	-0.136**	-0.073*	-0.103***	-0.049	-0.108***	-0.053	-0.077**	-0.099**	-0.069*	-0.0059
YD_####	0.071***	0.150***	-0.040***	-0.102***	-0.052***	-0.005	0.058***	0.077***	0.153***	0.165***	-0.095***	0.139***	-0.088***	0.087***
_cons	6.637	8.089	8.660	7.461	9.216	8.864	8.002	7.499	7.623	8.708	8.100	7.457	8.427	8.380

Table 35 continued

In VALUE	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
Rho	0.318	0.084	0.123	0.257	0.087	0.109	0.067	0.171	0.166	0.144	0.283	0.187	0.102	-0.019
Lambda	-0.519	-0.154	-0.238	-0.373	-0.190	-0.204	-0.159	-0.250*	-0.246	-0.182	-0.357	-0.317	-0.203	-0.079
Sigma	0.207***	0.279***	0.225***	0.233***	0.216***	0.186***	0.186***	0.172***	0.205***	0.179***	0.183***	0.177***	0.179***	0.160***

*** significant at 0.01 level, ** significant at 0.05 level, * significant at 0.1 level

coefficients ranged from -0.0018 to -0.0034. In the period1996-1997, the view of the former oil wells site had positive association with the sales price of homes, the coefficient at 0.0023.

7.3 Comparison of Log-linear Regressions in Two Year Periods

To compare the magnitude of those log-linear coefficients under standardized variances among each model, standardized coefficients are presented in Table 36. In this table, association of variables to the housing price may not be directly interpreted; however, the magnitude of each coefficient across models can be examined and compared.

As shown in Table 36 generally nature preserve showed decrease and oil well site showed increase in negative association after the conversion in 1994. Standardized coefficients of distance to nature preserve gradually increase after the conversion of the neighboring site, meaning decrease in positive association with housing price. In the models, the positive association of proximity remains between -0.061and -0.147 in first six periods and decreases to 0.029 in last 8 periods. On the other hand, standardized coefficients of distance to oil wells site show an increasing trend in negative association after the conversion in 1994. Before the conversion, negative impact of DIST_NP is more robust than the impact of DIST_OW. After the conversion, the gap narrows down and eventually in the last four periods the impact of DIST_OW surpasses that of DIST_NP. From year 2004 to 2011, both the nature preserve and oil wells site coefficients remain around -0.7. In the last period, DIST_OW presents much stronger negative association to the value of single family houses than previous periods. Figure 17 shows the difference between beta coefficients of DIST_NP and DIST_OW. The gap between the two coefficients was the largest in the period 1992-93 and it gradually narrowed for 10 years. In period 2004-05, the difference between DIST_NP and DIST_OW were 0.005 and remained near to zero until the period 2010-11. Figure 16 depicts that the gap dissolved from year 2004 to 2011. In the period 2012 and 2013, single family houses near the former oil wells site had more premium than the ones near the nature preserve holding other factors constant.

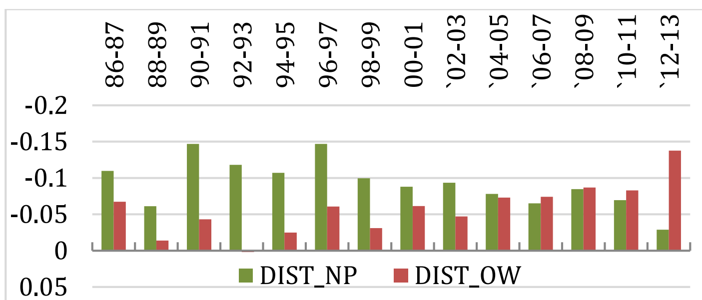


Figure 16 Standardized coefficients of DIST_NP and DIST_OW

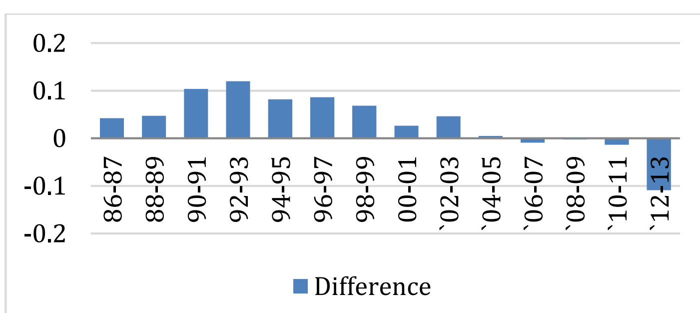


Figure 17 Difference between standardized coefficients of DIST_NP and DIST_OW

Table 36 Standardized coefficients of log-linear Regressions in two year periods

ln VALUE	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
R^2	0.675	0.527	0.553	0.512	0.559	0.685	0.691	0.714	0.634	0.559	0.471	0.647	0.690	0.728
DIST_NP	-0.110	-0.061***	-0.147***	-0.118***	-0.107***	-0.147***	-0.100***	-0.088***	-0.093***	-0.078***	-0.065**	-0.085***	-0.070***	-0.029
DIST_OW	-0.067	-0.014	-0.043*	0.002	-0.025	-0.061***	-0.031*	-0.061***	-0.047**	-0.073***	-0.074**	-0.087***	-0.083***	-0.138***
VIEW_NP_INT	0.013	0.049***	0.038**	0.063***	0.027	0.046***	0.022	0.044***	0.051***	0.051***	0.035	0.022	0.047***	0.032**
VIEW_OW_INT	-0.018	-0.046***	-0.060***	-0.013	0.021	0.032**	-0.012	-0.027**	-0.019	0.013	-0.0018	0.0031	-0.0092	0.0093
ln_SQFT	0.398***	0.223***	0.336***	0.261***	0.302***	0.364***	0.342***	0.397***	0.391***	0.423***	0.409***	0.392***	0.438***	0.483***
ln_LOTSIZE	0.219***	0.325***	0.160***	0.318***	0.237***	0.208***	0.266***	0.254***	0.227***	0.156***	0.176***	0.187***	0.179***	0.190***
AGE	-0.173***	-0.0073	-0.143***	-0.076***	-0.131***	-0.156***	-0.075***	-0.063***	-0.010	-0.0090	-0.013	-0.092***	-0.097***	-0.057***
D_pool	0.054	0.085***	0.121***	0.016	0.071***	0.063***	0.081***	0.081***	0.063***	0.074***	0.048**	0.041**	0.058***	0.057***
D_spa	0.0056	0.038**	0.033*	0.038*	0.019	0.022	0.027**	-0.0020	0.014	0.0036	-0.035	0.0030	0.019	0.0094
D_MillsAct	0.049	0.047***	0.017	0.035*	-0.0095	0.065***	0.039***	0.035***	0.017	-0.017	0.014	0.019	&&&	0.043***
D_garage	0.107***	0.104***	0.017	0.019	0.026	0.018	0.031**	0.049***	0.013	0.064***	-0.0030	0.023	-0.012***	-0.017
DIST_Shop	0.055	0.036*	0.070***	0.0070	0.039*	0.043**	0.085***	0.061***	0.044**	0.039**	0.013	0.043**	0.074***	0.026
DIST_ES	-0.019	-0.033	-0.025	-0.021	-0.023	-0.046**	-0.020	-0.048***	-0.019	-0.039**	0.0044	-0.039*	-0.062***	-0.019
DIST_Park_LC	-0.047	-0.043***	-0.049**	-0.047**	-0.065***	-0.055***	-0.066***	-0.073***	0.0028	-0.0077	-0.045	-0.058***	-0.057***	-0.030*
DIST_golf	-0.121**	-0.266***	-0.238***	-0.223***	-0.199***	-0.242***	-0.248***	-0.259***	-0.221***	-0.208***	-0.157***	-0.235***	-0.265***	-0.128***
SD_100	0.072**	0.090	0.093***	0.034	0.058**	0.047**	0.095***	0.109***	0.068***	0.082***	0.117***	0.081***	0.081***	0.010
D_highway	-0.084***	-0.0044	-0.027	-0.032	-0.048**	-0.027*	-0.037**	-0.013	-0.049***	-0.026	-0.078***	-0.036*	-0.034**	0.0089
YD_1991	0.095***	0.186***	-0.028	-0.146***	-0.052***	-0.0014	0.087***	0.112***	0.219***	0.298***	-0.168***	-0.187***	-0.113***	0.165***

*** significant at 0.01 level, ** significant at 0.05 level, * significant at 0.1 level

The coefficients of view of oil well were not statistically significant in 10 of 14 periods. Thus, the coefficients have no statistical meaning. Figure 18 shows both coefficients of view of nature preserve and oil wells site. Generally, the view of oil well site is negatively associated with the housing value throughout the entire period while the view of nature preserve has been a premium.

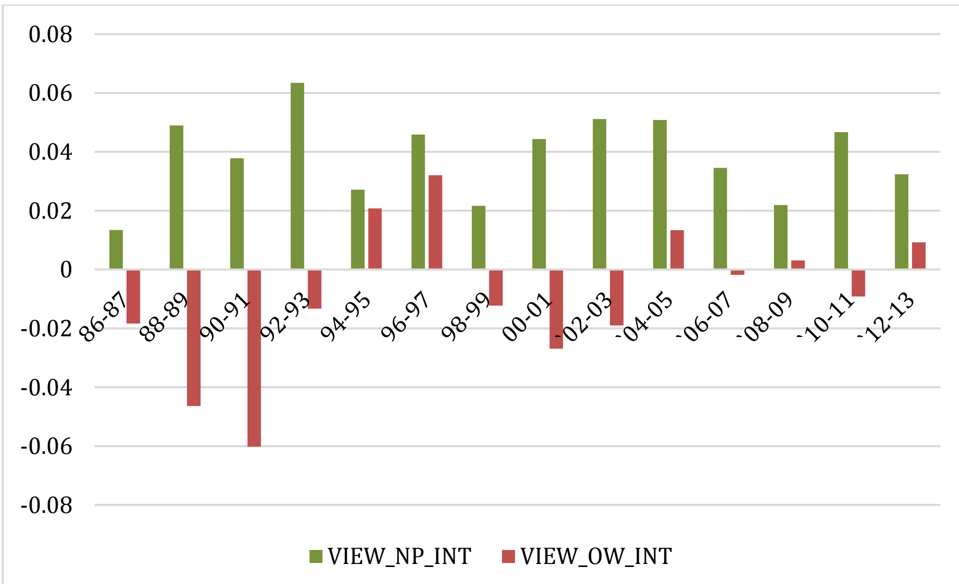


Figure 18 Standardized coefficients of VIEW_NP_INT and VIEW_OW_INT

In order to examine the validity of the trends, decrease in negative association of the nature preserve and increase in negative association of the former oil wells site, other locational variables were examined. Figure 19 presents changes in magnitude of impacts for each locational variable over the 14 study periods. The distance to golf course had the strongest impact of all, and it was significant throughout the study period. The changes in the impact did not show any trend of decreasing or increasing. Distance to park and elementary school also had been negative attributes to the sales price of single family houses except for one period. The negative association of parks was higher on the periods from 1986 to 2001 and from 2006 to 2013 than elementary schools. DIST_Park is statistically significant for most periods except for 1986 to 1989 and 2002 to 2006, while DIST_ES was not statistically significant for more than half of the study period. Distance to shopping mall always has a positive effect on the sales price of near by single family houses. None of the locational variables show trends of decreasing or increasing.

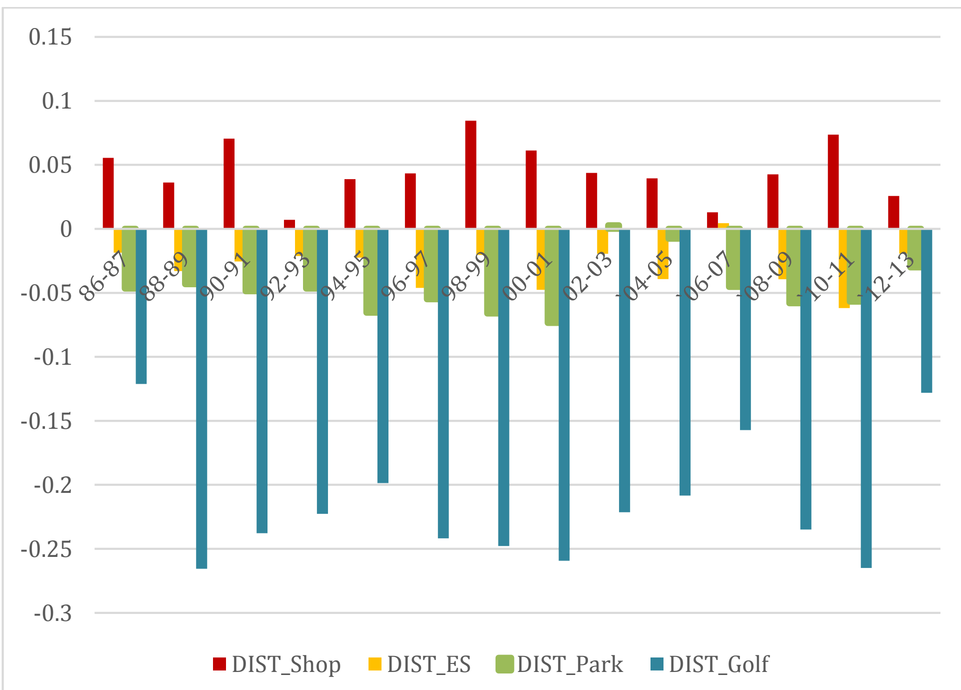


Figure 19 Standardized coefficients of locational variables

7.4 Comparison of Spatial Regressions in Two Year Periods

To compare the magnitude of those SAC coefficients under standardized variances among each model, standardized coefficients are presented in Table 37. In this table, association of variables to the housing price may not be directly interpreted; however, the magnitude of each coefficient across models can be examined and compared.

The SAC models presented R^2 ranging from 0.47 to 0.74. All the F-tests were significant at 0.001 level. As mentioned above, spatial autoregressive parameters were all significant at 0.001 level. All the coefficients and their significance are listed in Table 37.

Like the results from log-linear model, proximity to nature preserve showed decrease and proximity to oil well site showed increase in positive association after the conversion in 1994. In these spatial models, coefficients of distance to nature preserve gradually increase after the conversion of the neighboring site, meaning decrease in positive association to housing price. In the models, the positive association between proximity and the sales price remains between -0.039 and -0.063 in first six periods and decreases to 0.009 at the last period. On the other hand, standardized coefficients of distance to oil wells site show an increasing trend in negative association after the conversion in 1994. As shown in Figure 20, negative impact of DIST_NP is much stronger than the impact of DIST_OW before the conversion. After the conversion, the gap narrows down and eventually at the last four periods, the impact of DIST_OW surpasses that of DIST_NP significantly. Compared to log-linear standardized coefficients, DIST_NP is relatively weaker throughout the entire period. The gap before the conversion, when DIST_NP had a stronger negative association, is smaller than that of log-linear results. Also, 10 years after the conversion when DIST_OW had more premiums, the impact of DIST_OW began to surpass the impact of DIST_NP more rapidly. From year 2004 to 2013, the coefficients of distance to oil wells site significantly decreased from -0.029 to -0.071, while the coefficients of nature preserve increase from -0.029 to -0.009. From 1994 to 2003, ten years after the conversion, DIST_NP had stronger negative association with the value of single family houses, but the gap was narrowing.

Figure 20 Standardized coefficients of DIST_NP and DIST_OW (SAC model)

Table 37 Standardized coefficients of SAC models in two year periods

	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
R^2	0.655	0.476	0.546	0.417	0.566	0.667	0.672	0.614	0.546	0.480	0.379	0.629	0.654	0.745
DIST_NP	-0.049***	-0.039***	-0.063***	-0.052***	-0.047***	-0.058***	-0.046***	-0.039***	-0.046***	-0.029***	-0.017**	-0.028***	-0.031***	-0.0090
DIST_OW	-0.032*	-0.023**	-0.033***	-0.018*	-0.038***	-0.038***	-0.042***	-0.035***	-0.030***	-0.029***	-0.035***	-0.043***	-0.054***	-0.071***
VIEW_NP_INT	0.0042	0.018**	0.012**	0.014**	0.0067	0.013**	0.0071	0.016***	0.013***	0.016**	0.010	0.0024	0.011	0.0087
VIEW_OW_INT	-0.0070	-0.017***	-0.021***	-0.0089	0.0043	0.015***	-0.0051	-0.011**	-0.0065	0.0036	0.010	0.0021	-0.0038	0.0045
ln_SQFT	0.141***	0.084***	0.114***	0.083***	0.111***	0.126***	0.126***	0.129***	0.139***	0.114***	0.114***	0.128***	0.143***	0.152***
ln_LOTSIZE	0.071***	0.121***	0.043***	0.099***	0.072***	0.071***	0.084***	0.081***	0.075***	0.039***	0.044***	0.055***	0.052***	0.062***
AGE	-0.088***	-0.0013	-0.054***	-0.049***	-0.051***	-0.051***	-0.021***	-0.031***	-0.0055	-0.010	-0.0032	-0.043***	-0.037***	-0.023***
D_pool	0.019	0.032***	0.040***	0.0019	0.019***	0.024***	0.032***	0.029***	0.023***	0.023***	0.017***	0.019***	0.023***	0.018***
D_spa	0.0014	0.013**	0.011*	0.011*	0.0048	0.008	0.0088**	-0.0023	0.0023	0.000086	-0.011**	0.0011	0.0052	0.0017
D_MillsAct	0.010	0.018***	0.0037	0.012*	0.0065	0.016***	0.010**	0.014***	0.0063	-0.0061	0.0042	0.011	-	0.013***
D_garage	0.041***	0.045***	0.0092	0.0058	0.014**	0.0072	0.016***	0.015***	0.0069	0.014***	0.0035	0.012**	-0.0030	-0.0055
DIST_Shop	0.013	-0.00021	0.015*	-0.0085	-0.0063	-0.000030	0.0095	0.0014	0.0013	0.0017	-0.0050	-0.0048	0.0021	-0.014*
DIST_ES	-0.004	-0.0068	-0.0090	-0.011	-0.011	-0.0088	-0.0029	-0.0074	-0.0058	-0.0092	0.0015	-0.0055	-0.017**	-0.006
DIST_Park_LC	-0.021	-0.016**	-0.016**	-0.021***	-0.016	-0.022***	-0.027***	-0.032***	-0.0072	-0.0029	-0.014**	-0.012*	-0.0093	-0.014**
DIST_golf	-0.048**	-0.091***	-0.096***	-0.072***	-0.067**	-0.071***	-0.070***	-0.079***	-0.068***	-0.060***	-0.030***	-0.069***	-0.069***	-0.029***
SD_100	0.017	0.013	0.023**	0.0024	0.013***	0.0063	0.013*	0.024***	0.0087	0.017***	0.021***	0.016**	0.018**	-0.012*
D_highway	-0.036***	-0.0050	-0.010	-0.018**	-0.020	-0.011*	-0.015***	-0.0072	-0.016***	-0.0076	-0.011*	-0.014**	-0.010	-0.0009
YD_1987	0.0056***	0.030***	-0.0068***	-0.019***	-0.010***	-0.0009	0.012***	0.016***	0.031***	0.031***	-0.015***	-0.025***	-0.016***	0.014***
_cons	8.281*	11.146***	10.514***	9.400***	10.788***	10.548***	11.046***	10.262***	10.471***	11.223***	9.957***	10.128***	10.939***	12.129***

Table 37 continued

	1986-1987	1988-1989	1990-1991	1992-1993	1994-1995	1996-1997	1998-1999	2000-2001	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
Rho	0.318	0.084	0.123	0.257	0.087	0.109	0.067	0.171	0.166	0.144	0.283	0.187	0.102	-0.019
Lambda	-0.519	-0.154	-0.238	-0.373	-0.190	-0.204	-0.159	-0.250*	-0.246	-0.182	-0.357	-0.317	-0.203	-0.079
Sigma	0.207***	0.279***	0.225***	0.233***	0.216***	0.186***	0.186***	0.172***	0.205***	0.179***	0.183***	0.177***	0.179***	0.160***

*** significant at 0.01 level, ** significant at 0.05 level, * significant at 0.1 level

Compared to the log-linear model with standardized coefficients, the results show similar trends in changes of the impacts on the sales price. Figure 21 shows the difference between coefficients of DIST_NP and DIST_OW. The gap between the two coefficients was the largest in the period 1992-93 and the period 2012-13 on the positive side and negative side, respectively. The major difference from log-linear models with standardized coefficients is that impact of DIST_OW is relatively much stronger than the impact of DIST_NP in the last period. In period 1992-93, the difference was 0.034, DIST_NP being lower. In contrast, in period 2012-13, the difference was 0.062, DIST_NP being higher. In addition, the gap dissolved from 1998 to 2005 while it dissolved from 2004 to 2011 in the log-linear model. Beginning from year 2006, single family houses near the former oil wells site had more premium than the ones near the nature preserve holding other factors constant.

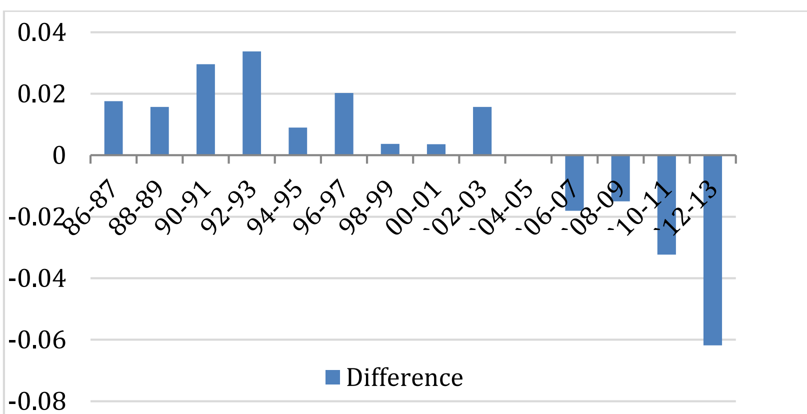


Figure 21 Difference between standardized coefficients of DIST_NP and DIST_OW (SAC model)

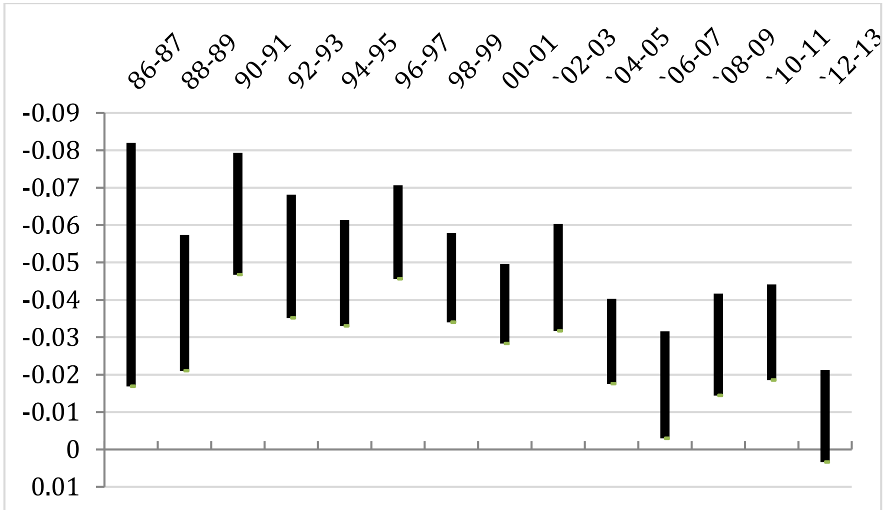


Figure 22 Confidence intervals of standardized coefficients for DIST_NP (SAC model)

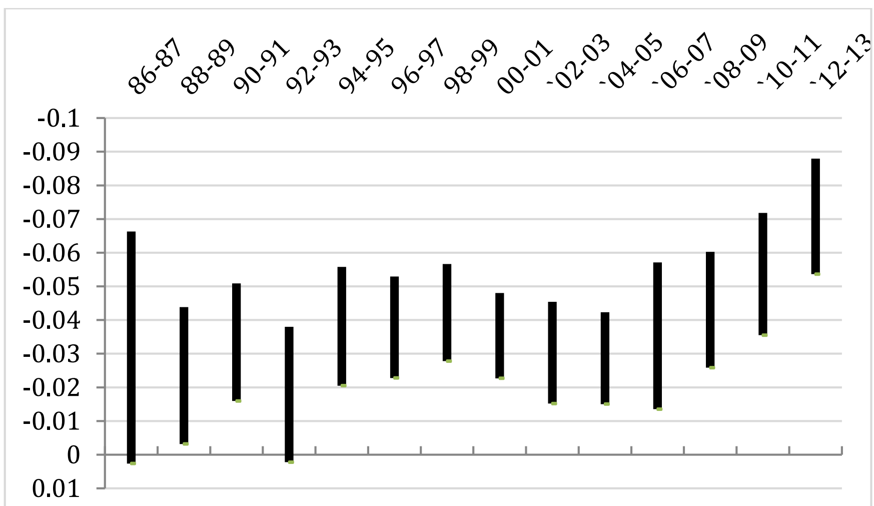


Figure 23 Confidence intervals of standardized coefficients for DIST_OW (SAC model)

To test the difference between beta coefficients across models, confidence intervals are graphed. Cumming (2009) demonstrated that two coefficients are statistically different from each other, when 95% confidence interval of each coefficient does not overlap more than 50%. As shown in Figure 22, coefficients of DIST_NP in most recent five periods are significantly higher and different from prior periods with an exception of the period from 1986 to 1989. On the other hand, as shown in Figure 23, coefficients for oil well site are not significantly different from each other across the models; however, the coefficient for the most recent period is significantly different from rest of the coefficients.

Similar to the result of the log-linear model, the coefficients of view of oil well were not statistically significant in nine of 14 models. Thus, the coefficients have no statistical meaning. Figure 24 shows both coefficients of view of nature preserve and oil wells site. In log-linear models, the view of oil well site is negatively associated with the housing value throughout the entire period and the view of nature preserve has been a premium. In these SAC models, the view of nature preserve increased the value of single family houses, while the view of oil wells site presented a mixed result of switching from an amenity to disamenity and vice versa.

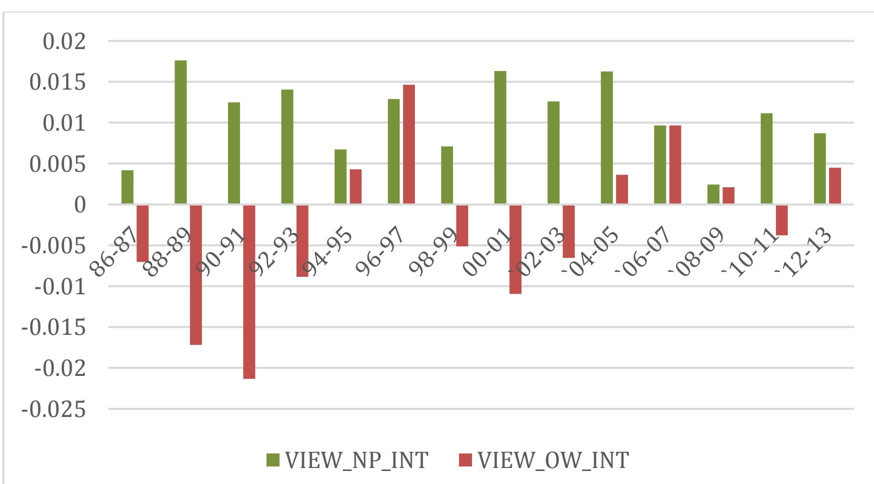


Figure 24 Standardized coefficients of VIEW_NP_INT and VIEW_OW_INT (SAC model)

In order to examine the validity of the trends, decrease in positive association of the nature preserve and increase in positive association of the former oil wells site, other locational variables were examined. Figure 25 presents changes in magnitude of impacts for each locational variable over the 14 study periods. Like the log-linear models, the distance to golf course had the strongest impact of all, and it was significant throughout the study period. In the log-linear models, the changes in the impact did not show any trend of decreasing or increasing, however, in the SAC models, it depicts slight decrease in the impact when they are compared before and after of the conversion in 1994. Distance to park had been negative attributes to the sales price of single family houses for the entire study period. The negative association of park also shows slight increase since 2002. DIST_Park had been statistically significant for most periods except for 1988 to 1989 and 2002 to 2006. From 2002 to 2006, DIST_Park had weaker association.

Elementary school also had been positive attributes to the sales price of single family houses except for the period of year 2006 and 2007. Distance to shopping mall presented a mixed result in the SAC model in regards to the sales price of near single family houses. Both DIST_ES and DIST_Shop had been statistically insignificant for more than half of the study period. These locational variables do not show trends of decreasing or increasing.

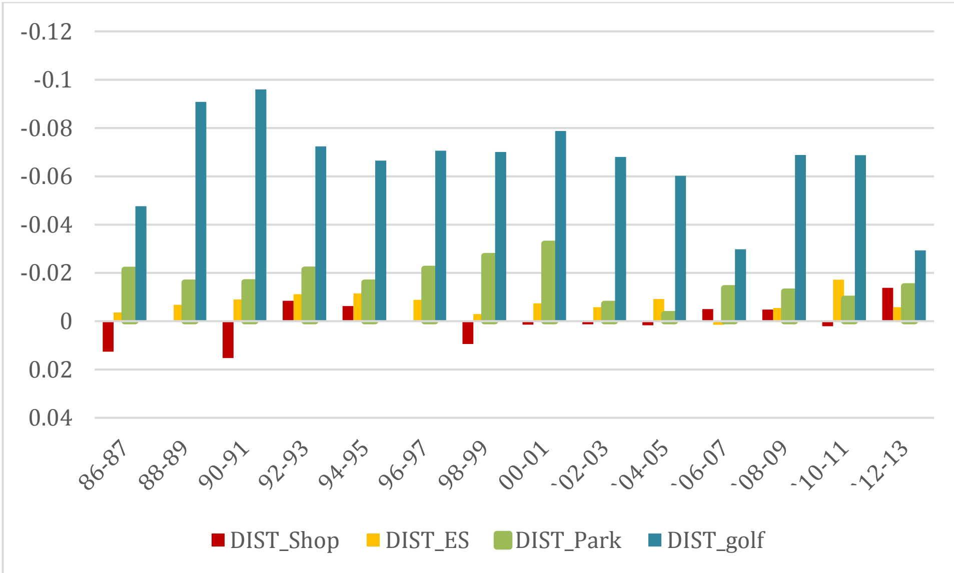


Figure 25 Standardized coefficients of locational variables (SAC model)

CHAPTER VIII

DISCUSSION AND CONCLUSION

This study expands the existing literature on impact of environmental amenities and disamenities on single family housing value by temporally and spatially examining changes in the effect of amenity and disamenity when disamenity is transformed into an amenity. Using a comprehensive dataset of actual sales price from housing transactions collected over a period of twenty-eight years, this study examined the changes in the impact of amenities and disamenities in the City of Whittier, CA before and after the conversion of oil wells sites into a nature preserve. The data was collected from 1986, when all oil wells sites were considered active, until the most recent sales transaction data in 2013. This study compares the impact in a series of fourteen two year periods. The 28 year study period includes four periods before the conversion and ten periods after the conversion. This structure allows for before-and-after comparison of the impact of the conversion on itself and near amenities in regards to housing sales prices. The spatial hedonic models in series of longitudinal analyses assisted to compare the effects of conversion and examine the recovery process over time across space.

8.1 Discussion

8.1.1 Validity of Spatial Hedonic Models

Spatial hedonic regressions were performed after testing for spatial dependency of the sales price included in the log-linear models. The diagnostic statistics for spatial autocorrelation, the Moran's I tests, Geary's C, and Lagrange Multiplier tests, were introduced following log-linear estimation. The tests indicated the presence of strong spatial autocorrelation among the sales prices of single family houses in each period. After a series of likelihood ratio tests and LM tests, spatial-autoregressive models with spatial autoregressive residuals, SAC, were selected to adjust for spatial dependency for each period.

The spatial-autoregressive model with spatial autoregressive residuals provided more significant coefficients for the independent variables of interest and contributed more to the explained variance when for estimating impact of surrounding environmental amenities and disamenities on the value of single family houses. Across the entire study period, SAC models provide statistically significant coefficients for the primary independent variables, distance to nature preserve and distance to oil wells site, with one exception of the DIST_NP coefficient at period 2012-13. This is a significant improvement from traditional log-linear model, which produced five coefficients that were not statistically significant. However, it did not provide more significant coefficients (about half) for the view of nature preserve and oil wells site variables. All the SAC models were tested for likelihood ratio test vs the log-linear models and were significant at 0.01 level.

8.1.2 Land Use Changes: Impact on Sales Prices of Single Family Houses

Previous two chapters presented results from log-linear models and spatial hedonic models. Both models presented similar results and trends of the impact of the nature preserve and the oil well sites. Before the conversion, positive association between the oil wells sites and the sales price was lower than that of the nature preserve. During the time, all of the DIST_OW coefficients, including normal and standardized ones in both the log-linear and the spatial models, were higher than those of DIST_NP, meaning that the oil site possessed lower positive impact to the single family houses than the original nature preserve. However, the oil well sites did not present negative impact on the housing market. One of the reasons is that the oil well sites were located in the middle of a hilly area surrounded by other nature preserves. Hillside residency was still a premium in spite of oil derricks and the associated traffic of heavy vehicles. Even in late 80s and early 90s, the impact of the oil well sites on the sales price was still positive for the site being surrounded by nature. This indicates that the oil well sites had been suppressing the value of the natural area but the negative association had not been strong enough to take over the positive association of the surrounding area. Nonetheless, the view of oil well sites had been negatively associated with the sales price. This, again, supports the explanation that the residents favored hillside residency but did not enjoy the view of the oil well sites.

In standardized SAC models, the magnitude of the positive impact of proximity to the oil wells site was the smallest in period 1992-93, which is right before the conversion. This was also the time when the developers and the city were planning to convert the oil well sites into a large housing development area, so the anticipation and expectation of the site being natural amenity did not convey. The residents were expecting another type of development on the former industrial area. Expectation of other developments on the site did not manifest positive impact on the existing single family housing valuation.

The earlier three periods also presented lower positive impact compared to the results in the periods after the conversion. The positive association of proximity to the former oil well sites increased significantly, from -0.18 in the previous period to -0.38 in the 1994-95 period. After the decision on the conversion to nature preserve instead of the housing development, the derricks were removed and the city engaged in recovering the physical aspect of the nature. Expectations from existing and potential residents that the site would become a natural amenity may have increased the value of the site. While the city added constant efforts to turn the site into the nature preserve, the positive impact remained at its initial increase until 2005. In the first 12 years after the conversion, the residents may have been aware of use and market value of the changed natural amenity, which led to initial increase in 1994. Starting from 2006, the positive association between the proximity to the former oil wells site and the value of single family houses began to increase rapidly. After twelve years of recovery, the residents began to recognize the site as an asset they would value for non-market and non-use purposes. This includes value that the residents appreciate for the existence, potential future resource for next generations, and intrinsic value of the nature itself.

On the other hand, the nature preserve, which is located adjacent to the restored oil well sites, presented distinctively high positive association to the sales price of single family houses until 2003 and has decreased since then. In both models, proximity to nature preserve was statistically significant and positive to the sales price. In the period 1990-91, the preserve had the highest impact in terms of both magnitude and actual price. As mentioned above, this was the time when the residents were not aware of what the oil well sites would become. The oil company proposed a housing development for their profit. It was in 1993 that the city bought the land from the oil company and began the discussion of transforming it into a nature preserve. The residents may have remained their preference on natural amenities over possible development area. Through these events, the nature preserve remained at its level of the positive impact until ten years after the conversion. Since 2004, when the former oil well sites started to gain the stronger positive impact apart from the initial increase in 1994, the positive association between the nature preserve and the housing value has decreased. It still retains its positive association but not in the same magnitude. Unlike the former oil well sites, the nature preserve has always had positive impact for its view.

Other structural and locational attributes also exhibit expected results in both the log-linear and spatial models. Among the structural variables, size of house and lot, age of structure, and existence of pool were highly significant. As expected, larger houses and lots had more premiums. Existence of a pool in a house increased the value by 2~4% on average. Age was another factor that significantly impacted the housing value. Participation in MillsAct program was a prominent factor that increased the value of the property by as high as 45% when it was significant. Like the existence of spa and garage, however, it was not statistically significant in several periods. While in some periods there simply were not enough sales of MillsAct properties to examine, when there were sufficient properties in the program they played a large role in the price—as much as a 45% increase. This is also the case for spa as well. All the results for structural variables concurred with previous literature and findings, except for the few coefficients that were not significantly different from zero.

The locational variables of the study also exhibited the expected results. The proximity to a golf course increased the value of single family houses most significantly among the locational variables. The impact was strong and statistically significant for the entire study period. Parks also affected the value of nearby properties, but their coefficients were not as low as the golf course. This may be due to the fact that golf courses are scarcer than parks and the houses near the golf course area are usually built with higher quality than the properties in typical housing development area. Lack of control variables like housing quality and neighborhood quality may have resulted in more premiums for being near to the golf course. Proximity to elementary school increased the value of single family homes for the entire study period except for 1996-97 period. Shopping malls and highways, on the other hand, were disamenities. While other locational variables do not show trends of either decreasing or increasing, the nature preserve and the oil wells site show decreasing and increasing impact on housing market after the conversion. This partially explains that the conversion have had impact on the market.

Land use diversity index of a neighborhood had a positive association with the value of single family houses. Properties in a neighborhood with diverse land use were higher valued than those in less diverse environment, holding other factors constant. The diversity of a neighborhood was associated with maximum of 10% of the average sales value. On average, a house in a neighborhood with completely diverse land use had 8% premium over a house in a neighborhood dominated by one land use, the single family residency. The impact does not show any trend in time over 28 years. It has constantly been positive at a similar magnitude.

8.1.3 Recovery and Trends in the Effect on Sales Prices of Single Family Houses

This research was initially expected to reveal an increased positive impact of the nature preserves following the removal of oil wells. Upon the conversion, the city introduced plans and measures to facilitate recreational use of the nature preserve. At the same time, the city also emphasized the conservation aspect of the nature preserve. These efforts would have turned the mountain into an attractive amenity residents would want to live near to. This assumption is partially right that this former oil wells site, which became a nature preserve in 1994, recovered its positive association with housing prices. Before the transition, the oil wells suppressed the value of nature they were sitting on. When they were removed and the site was transformed into natural amenity, the positive impact started to grow. During the last five periods, 10 years after the conversion, the positive impact of the former oil well sites surpassed the positive impact of the neighboring never-developed nature preserve.

As explained earlier, use and market value of the former oil well sites recovered soon after the conversion in 1994. There may have not been direct use values like logging or hunting; however, the residents may have benefited from its recreational and aesthetic value after the conversion. In addition to the use value, residents' expectation for future uses of the site may have changed at the point of the decision, showing an instant increase of the positive impact in 1994. This initial increase lasted for 10 years and it may be explained by the then projected uses of the property, the changes in residents' expectation and recovery of use values. After the instant increase in positive association between the proximity of the former oil well sites and the value of single family houses, it took another 10 years to start increasing again. During the period, the physical aspect of the site has fully recovered.

Upon the re-establishment of the physical aspect of the former oil wells site, the existence value would have started to recover. Then as the quality of the amenity enhanced, residents' willingness to pay to protect the resource for future generation would have increased. In other words, non-use value appreciated after the physical recovery that took 10 years since the conversion. Non-use value which includes existence, bequest, and altruism is related with the residents' perception of existence and quality. The residents' perception on the former oil wells site has changed 10 years after the conversion when the physical aspect of the site is fully recovered and the site became an amenity. The amenity once lost its intrinsic value had slowly recovered its original value as the resource recovered its diverse quality both in its existence and its quality.

While the positive impact of the former oil well sites grew, the impact of original nature preserve has diminished. Instead of an increase in the positive impact due to removal of the barrier that might have compromised its value, the conversion resulted in a decrease of its positive association to housing value. It remained at similar levels of positive association until 2003, 10 years after the conversion, when it started to decrease when the positive impact of the former oil wells site started to increase. These results suggest that oil wells did not depress the value of neighboring nature but instead they gave the amenity comparative advantage. The nature preserve could maintain its comparative advantage once the former oil well sites recovered its intrinsic value. As the former oil well site recovered both its use and non-use value, properties near the original nature preserve lost their comparative advantage over those near oil wells site, resulting in the decrease. Finally, 10 years after the conversion, both the original nature preserve and the former oil wells site have become a natural amenity.

In addition to the intrinsic value and comparative advantage, structure of the hedonic modeling adds to the explanation of the unexpected result. In the hedonic modeling, the price of any attribute is referred as the equilibrium marginal implicit price of the attribute, market premium to be paid for one more level of the attribute (Can, 1992). For each attribute except for structural attributes, the marginal implicit price will be limited within a certain range. Extensive land may result in extensive price of the house; however, adjacency to an amenity, like all the other locational and neighborhood characteristic, only increases the value to a certain point. Likewise, the marginal implicit price for natural amenity is limited in given circumstances. Price of a house is bounded by market price of the area and one attribute of a house would not drive the price to exceed a certain point in a short period of time, especially if the attribute is shared by neighboring properties. In other words, adjacency to a nature preserve, which is for the maximum marginal implicit price, would not increase the value of the property by unlimited margin. This is due to the fact that the environmental and neighborhood attributes are not completely non-exclusive and non-competitive; this is the same reason explained in the literature review that the nature is not appreciated enough considering its importance. With the limited marginal implicit price for natural amenities, properties near nature preserves may have been appreciated at its maximum marginal implicit price already. So, when the neighboring oil well sites had transformed into a nature preserve, there was not enough room for additional implicit price of natural amenities to enter the regression. The residents near the original nature preserve would not care about the neighboring industrial site since they were already enjoying the proximity to the nature preserve. This is why the positive impact of the original nature preserve did not increase after the conversion, and it also supports the argument of the comparative advantage.

8.2 Conclusion

Previous hedonic studies have revealed that both structural and neighborhood variables are important determinants of property values. Structural variables such as parcel size, structure square footage, age of house, and number of bedrooms and bathrooms are expected to have highly significant coefficients. Locational variables like distance to parks and central business districts have also demonstrated positive association to value of properties in previous studies (Donovan & Butry, 2011; More et al., 1988). Among the key variables of this research, the nature preserve variable was expected to have positive association between proximity and property values. On the other hand, the sign of the coefficients for the distance to the nearest oil well site was expected to be positive, meaning a negative impact to the single family housing valuation. In particular, the study was expected to reveal an increased positive impact from the nature preserves following the removal of oil wells. Upon the conversion, the city introduced plans and measures to facilitate recreational use of the nature preserve. At the same time, it also emphasized the conservation of the nature preserve. These efforts would have turned the mountain into a more attractive amenity residents would want to live near. In the same sense, a weaker association between the nature preserve and residential property values before 1993 was anticipated. It was assumed that before the transition the combined effect of nature and industry would have compromised the positive association that the nature preserve had on the residential properties. Residents' perception of the mountain areas would have not been significantly positive due to the oil well sites near to them.

However, the result of the study revealed otherwise. Assumption that the oil wells site compromised the positive associations of the neighboring nature preserve was wrong. Instead, as discussed above, the oil wells site had given a comparative advantage to the original nature preserve, which eventually diminished as the former oil wells site recovered as an amenity. Also, oil well sites did not have negative impact even before the conversion and the positive association between the original nature preserve and the sales price did not increase but decreased after the conversion. Through these unexpected findings, this study provided an opportunity to examine the underlying reason and theory for the changes the conversion further.

This study examined the process of changes in the impact of nature preserve on the property values after its designation. How long does it take to alter the residents' perception and preference and be accounted in the market? This study examines this timing. It also directly compared the impact of oil wells and nature preserves spatially and temporally and provided evidence of changes in the impact from one another, which previous literatures failed to examine. In the process, the nature preserve and its intrinsic value were studied. The result provides significant information regarding industry vs. nature related policy adoption and decision making for residents, planners, and related officials.

This study provides critical information for planners and policy makers regarding issues of preservation and development in regards to economy and equity in a community. The evidence of a disparity on access to and enjoyment of environmental amenity within a community was presented by revealing preference of residents by hedonic spatial regression. The comparative advantage and disadvantage is the evidence for the issue of equity in community planning. The State of California decided to purchase those oil well sites for preservation purposes when the companies were not making enough profit. Now with advanced technologies and higher oil price, the companies are seeking to reopen those sites and the City Council is supporting it for the tax and economic opportunities. However, what is often missing during deliberations is examining the before and after impact of such transitions on the value of residential properties and the disparity issues in the city. Comparison of the impacts over a long term period provides enhanced perspectives on the benefits and costs not only for residents but also for decision makers. In this sense, the result of this research can add to the deliberation on the process of projecting property values, examining pros and cons, practicing balanced community development, and making policies.

REFERENCES

Acharya, G., & Bennett, L. L. (2001). Valuing open space and land-use patterns in urban watersheds. *The Journal of Real Estate Finance and Economics, 22*(2), 221-237.

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. *American Journal of Agricultural Economics, 80*(1), 64-75.

Aldred, J. (1994). Existence value, welfare and altruism. *Environmental Values, 3*(4), 381-402.

Anderson, S. T., & West, S. E. (2006). Open space, residential property values, and spatial context. *Regional Science and Urban Economics, 36*(6), 773-789. doi: 10.1016/j.regsciurbeco.2006.03.007

Anselin, L. (1988). *Spatial econometrics: methods and models* (Vol. 4): Springer.

Anselin, L. (2002). Under the hood Issues in the specification and interpretation of spatial regression models. *Agricultural Economics, 27*(3), 247-267. doi: 10.1111/j.1574-0862.2002.tb00120.x

Anselin, L., Bera, A. K., Florax, R., & Yoon, M. J. (1996). Simple diagnostic tests for spatial dependence. *Regional Science and Urban Economics, 26*(1), 77-104.

Anselin, L., & Le Gallo, J. (2006). Interpolation of air quality measures in hedonic house price models: spatial aspects. *Spatial Economic Analysis, 1*(1), 31-52.

Attfield, R. (1998). Existence value and intrinsic value. *Ecological Economics, 24*(2), 163-168.

Bajari, P., & Benkard, C. L. (2005). Demand Estimation with Heterogeneous Consumers and Unobserved Product Characteristics: A Hedonic Approach. [Article]. *Journal of Political Economy, 113*(6), 1239-1276.

Barnett, A. P., & Ason Okoruwa, A. (1993). Application of Geographic Information Systems in site selection and location analysis. *Appraisal Journal, 61*, 245-245.

Bastian, C. T., McLeod, D. M., Germino, M. J., Reiners, W. A., & Blasko, B. J. (2002). Environmental amenities and agricultural land values: a hedonic model using geographic information systems data. *Ecological Economics, 40*(3), 337-349. doi: 10.1016/s0921-8009(01)00278-6

Batsell, R. R., & Louviere, J. J. (1991). Experimental analysis of choice. *Marketing letters, 2*(3), 199-214.

Berlyne, D. E. (1974). *Studies in the new experimental aesthetics: Steps toward an objective psychology of aesthetic appreciation*: Hemisphere.

Bertrand, M., Duflo, E., & Mullainathan, S. (2002). How much should we trust differences-in-differences estimates? : National Bureau of Economic Research.

Bible, D. S. (1995). Using GIS to enhance MLS. *Appraisal Journal, 63*, 440-440.

Bin, O., Landry, C. E., & Meyer, G. F. (2009). Riparian buffers and hedonic prices: a quasi-experimental analysis of residential property values in the Neuse River basin. *American Journal of Agricultural Economics, 91*(4), 1067-1079.

Bockstael, N. E., & McConnell, K. E. (2007). *Environmental and resource valuation with revealed preferences: A theoretical guide to empirical models*: Springer Dordrecht.

Bolitzer, B., & Netusil, N. R. (2000). The impact of open spaces on property values in Portland, Oregon. *Journal of Environmental Management, 59*(3), 185-193. doi: 10.1006/jema.2000.0351

Bowen, W. M., Mikelbank, B. A., & Prestegaard, D. M. (2001). Theoretical and empirical considerations regarding space in hedonic housing price model applications. *Growth and Change, 32*(4), 466-490.

Box, G. E. P., & Cox, D. R. (1964). An analysis of transformations. *Journal of the Royal Statistical Society. Series B (Methodological)*, 211-252.

Boxall, P. C., Adamowicz, W. L., Swait, J., Williams, M., & Louviere, J. (1996). A comparison of stated preference methods for environmental valuation. *Ecological Economics, 18*(3), 243-253.

Boxall, P. C., Chan, W. H., & McMillan, M. L. (2005). The impact of oil and natural gas facilities on rural residential property values: a spatial hedonic analysis. *Resource and Energy Economics, 27*(3), 248-269.

Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management, 92*(10), 2763-2773. doi: 10.1016/j.jenvman.2011.06.019

Bui, L. T. M., & Mayer, C. J. (2003). Regulation and capitalization of environmental amenities: Evidence from the toxic release inventory in Massachusetts. *Review of Economics and statistics, 85*(3), 693-708.

Can, A. (1990). The measurement of neighborhood dynamics in urban house prices. *Economic Geography*, 254-272.

Can, A. (1992). Specification and estimation of hedonic housing price models. *Regional Science and Urban Economics, 22*(3), 453-474.

Case, K. E., & Shiller, R. J. (1987). Prices of single family homes since 1970: New indexes for four cities: National Bureau of Economic Research Cambridge, Mass., USA.

Cheshire, P., & Sheppard, S. (1995). On the price of land and the value of amenities. *Economica*, 247-267.

Cho, S.-H., Poudyal, N. C., & Roberts, R. K. (2008). Spatial analysis of the amenity value of green open space. *Ecological Economics, 66*(2–3), 403-416. doi: 10.1016/j.ecolecon.2007.10.012

Cho, S. H., Lambert, D. M., Kim, S. G., Roberts, R. K., & Park, W. M. (2011). Relationship between value of open space and distance from housing locations within a community. *Journal of geographical systems, 13*(4), 393-414.

Clarke, R. V. G. (1997). *Situational crime prevention*: Criminal Justice Press Monsey, NY.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., . . . van den Belt, M. (1997). The value of the world's ecosystem services and natural capital. [10.1038/387253a0]. *Nature, 387*(6630), 253-260.

Crompton, J. L. (2005). The impact of parks on property values: empirical evidence from the past two decades in the United States. *Managing Leisure, 10*(4), 203-218.

Cropper, M. L., Leland, B. D., & McConnell, K. E. (1988). On the Choice of Funtional Form for Hedonic Price Functions. *The Review of Economics and Statistics, 70*(4), 668-675.

Darling, A. H. (1973). Measuring benefits generated by urban water parks. *Land economics*, 22-34.

Day, B., Bateman, I., & Lake, I. (2004). Omitted locational variates in hedonic analysis: a semiparametric approach using spatial statistics: Working paper, University of East Anglia, Norwich, UK.

De Vor, F., & de Groot, H. L. F. (2011). The impact of industrial sites on residential property values: a hedonic pricing analysis from the Netherlands. *Regional Studies, 45*(5), 609-623.

Deaton, B. J., & Hoehn, J. P. (2004). Hedonic analysis of hazardous waste sites in the presence of other urban disamenities. *environmental science & policy, 7*(6), 499-508.

Des Rosiers, F., Lagana, A., Thériault, M., & Beaudoin, M. (1996). Shopping centres and house values: an empirical investigation. *Journal of Property Valuation and Investment, 14*(4), 41-62.

Des Rosiers, F., Thériault, M., & Villeneuve, P.-Y. (2000). Sorting out access and neighbourhood factors in hedonic price modelling. *Journal of property investment & finance, 18*(3), 291-315.

Donovan, G. H., & Butry, D. T. (2011). The effect of urban trees on the rental price of single-family homes in Portland, Oregon. *Urban Forestry & Urban Greening, 10*(3), 163-168. doi: 10.1016/j.ufug.2011.05.007

Duke, J. M., & Aull-Hyde, R. (2002). Identifying public preferences for land preservation using the analytic hierarchy process. *Ecological Economics, 42*(1), 131-145.

Elhorst, J. P. (2014). *Spatial econometrics: from cross-sectional data to spatial panels*: Springer.

Feagin, R. A., Martinez, M. L., Mendoza-Gonzalez, G., & Costanza, R. (2010). Salt marsh zonal migration and ecosystem service change in response to global sea level rise: a case study from an urban region. *Ecology and Society, 15*(4), 14.

Flower, P. C., & Ragas, W. R. (1994). The effects of refineries on neighborhood property values. *Journal of Real Estate Research, 9*(3), 319-338.

Forman, E. H., & Gass, S. I. (2001). The analytic hierarchy process—an exposition. *Operations research, 49*(4), 469-486.

Freeman Iii, A. M. (2003). *The measurements of environmental and resource values: theory and methods*: RFF press.

Fung, D. S., Kung, H., & Barber, M. C. (1995). The application of GIS to mapping real estate values. *Appraisal Journal, 63*, 445-445.

Garrod, G. D., & Willis, K. G. (1992). Valuing goods' characteristics: an application of the hedonic price method to environmental attributes. *Journal of Environmental Management, 34*(1), 59-76.

Geoghegan, J., Lynch, L., & Bucholtz, S. (2003). Capitalization of open spaces into housing values and the residential property tax revenue impacts of agricultural easement programs. *Agricultural and Resource Economics Review, 32*(1), 33-45.

Geoghegan, J., Wainger, L. A., & Bockstael, N. E. (1997). Spatial landscape indices in a hedonic framework: an ecological economics analysis using GIS. *Ecological Economics, 23*(3), 251-264.

Germino, M. J., Reiners, W. A., Blasko, B. J., McLeod, D., & Bastian, C. T. (2001). Estimating visual properties of Rocky Mountain landscapes using GIS. *Landscape and Urban Planning, 53*(1), 71-83.

Goodman, A. C., & Kawai, M. (1982). Permanent income, hedonic prices, and demand for housing: new evidence. *Journal of Urban Economics, 12*(2), 214-237.

Grislain-Letrémy, C., & Katossky, A. (2014). The impact of hazardous industrial facilities on housing prices: A comparison of parametric and semiparametric hedonic price models. *Regional Science and Urban Economics, 49*, 93-107.

Groff, E., & McCord, E. S. (2012). The role of neighborhood parks as crime generators. *Security journal, 25*(1), 1-24.

Halvorsen, R., & Pollakowski, H. O. (1981). Choice of functional form for hedonic price equations. *Journal of Urban Economics, 10*(1), 37-49. doi: 10.1016/0094-1190(81)90021-8

Hamilton, S. E., & Morgan, A. (2010). Integrating lidar, GIS and hedonic price modeling to measure amenity values in urban beach residential property markets. *Computers, Environment and Urban Systems, 34*(2), 133-141. doi: 10.1016/j.compenvurbsys.2009.10.007

Hamilton, S. W., & Schwann, G. M. (1995). Do high voltage electric transmission lines affect property value? *Land economics*, 436-444.

Hanley, N. (1992). Are there environmental limits to cost benefit analysis? *Environmental and Resource Economics, 2*(1), 33-59.

Harrison, D., & Rubinfeld, D. L. (1978). Hedonic housing prices and the demand for clean air. *Journal of environmental economics and management, 5*(1), 81-102.

Heal, G. (2000). *Nature and the marketplace: Capturing the value of ecosystem services*: Island Press.

Heintzelman, M. D., & Tuttle, C. M. (2012). Values in the wind: a hedonic analysis of wind power facilities. *Land economics, 88*(3), 571-588.

Irwin, E. G. (2002). The effects of open space on residential property values. *Land economics, 78*(4), 465-480.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective*: Cambridge University Press.

Kelejian, H., & Prucha, I. (1998). A Generalized Spatial Two-Stage Least Squares Procedure for Estimating a Spatial Autoregressive Model with Autoregressive Disturbances. *The Journal of Real Estate Finance and Economics, 17*(1), 99-121. doi: 10.1023/a:1007707430416

Ketkar, K. (1992). Hazardous waste sites and property values in the state of New Jersey. *Applied Economics, 24*(6), 647-659.

Kong, F., Yin, H., & Nakagoshi, N. (2007). Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: A case study in Jinan City, China. *Landscape and Urban Planning, 79*(3–4), 240-252. doi: 10.1016/j.landurbplan.2006.02.013

Kuminoff, N. V., & Pope, J. C. (2009). Capitalization and welfare measurement in the hedonic model: Department of Agricultural and Applied Economics Working Paper.

Lake, I. R., Lovett, A. A., Bateman, I. J., & Day, B. (2000). Using GIS and large-scale digital data to implement hedonic pricing studies. *International Journal of Geographical Information Science, 14*(6), 521-541.

Lake, I. R., Lovett, A. A., Bateman, I. J., & Langford, I. H. (1998). Modelling environmental influences on property prices in an urban environment. *Computers, Environment and Urban Systems, 22*(2), 121-136.

Lancaster, K. J. (1966). A new approach to consumer theory. *The journal of political economy, 74*(2), 132-157.

LeSage, J., & Pace, R. K. (2010). *Introduction to spatial econometrics*: CRC press.

Li, W., & Saphores, J.-D. (2012). Assessing Impacts of Freeway Truck Traffic on Residential Property Values. *Transportation Research Record: Journal of the Transportation Research Board, 2288*(-1), 48-56. doi: 10.3141/2288-06

Lockard, J. S. (1980). *The evolution of human social behavior*: Elsevier Science Ltd.

Loomis, J. B. (2000). Environmental valuation techniques in water resource decision making. *Journal of water resources planning and management, 126*(6), 339-344.

Loomis, J. B., & Walsh, R. G. (1997). *Recreation economic decisions; comparing benefits and costs*: Venture Publishing Inc.

Lutzenhiser, M., & Netusil, N. R. (2001). The effect of open spaces on a home's sale price. *Contemporary Economic Policy, 19*(3), 291-298.

Maclennan, D. (1977). Some thoughts on the nature and purpose of house price studies. *Urban Studies, 14*(1), 59-71.

Mahan, B. L., Polasky, S., & Adams, R. M. (2000). Valuing urban wetlands: a property price approach. *Land economics*, 100-113.

Mansfield, C., Pattanayak, S. K., McDow, W., McDonald, R., & Halpin, P. (2005). Shades of green: measuring the value of urban forests in the housing market. *Journal of Forest Economics, 11*(3), 177-199.

Mark, J., & Goldberg, M. (1988). Multiple regression analysis and mass assessment: A review of the issues. *Appraisal Journal, 56*(1), 89-109.

McConnell, V., & Walls, M. A. (2005). *The value of open space: Evidence from studies of nonmarket benefits*: Resources for the Future Washington, DC.

McGarigal, K., & Marks, B. J. (1995). Spatial pattern analysis program for quantifying landscape structure. *Gen. Tech. Rep. PNW-GTR-351. US Department of Agriculture, Forest Service, Pacific Northwest Research Station*.

McVay, S., Katcher, A., McCarthy, C., Wilkins, G., Ulrich, R., Shepard, P., . . . Nelson, R. (1995). *The biophilia hypothesis*: Island Press.

Meyer, B. D. (1994). Natural and quasi-experiments in economics: National Bureau of Economic Research Cambridge, Mass., USA.

More, T. A., Averill, J. R., & Stevens, T. H. (1996). Values and economics in environmental management: a perspective and critique. *Journal of Environmental Management, 48*(4), 397-409.

More, T. A., Stevens, T., & Allen, P. G. (1988). Valuation of urban parks. *Landscape and Urban Planning, 15*(1), 139-152.

Morris, C. (1956). Varieties of human value.

Muehlenbachs, L., Spiller, E., & Timmins, C. (2014). The housing market impacts of shale gas development: National Bureau of Economic Research.

Mundy, B., & McLean, D. (1998). Using the contingent value approach for natural resource and environmental damage applications. *Appraisal Journal, 66*, 290-297.

NationalResearchCouncil. (2005). *Valuing Ecosystem Services: Toward Better Environmental Decision-Making*.

Neumann, B. C., Boyle, K. J., & Bell, K. P. (2009). Property price effects of a national wildlife refuge: Great Meadows National Wildlife Refuge in Massachusetts. *Land Use Policy, 26*(4), 1011-1019. doi: 10.1016/j.landusepol.2008.12.008

Nicholls, S. (2002). *Does Open Space Pay?: Measuring the Impacts of Green Spaces on Property Values and the Property Tax Base.* Texas A & M University.

Nicholls, S., & Crompton, J. L. (2005). The impact of greenways on property values: Evidence from Austin, Texas. *Journal of Leisure Research, 37*(3), 321.

Nichols, J. B., Oliner, S., & Mulhall, M. R. (2010). *Commercial and residential land prices across the United States*: Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board.

O'Neill, J. (1992). The varieties of intrinsic value. *The Monist, 75*(2), 119-137.

O'Sullivan, S. (2003). Economics Principles in Action (California Edition).

Palmer, J. F. (2004). Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning, 69*(2), 201-218.

Palmquist, R. B. (1984). Estimating the Demand for the Characteristics of Housing. *The Review of Economics and Statistics*, 394-404.

Parmeter, C., & Pope, J. (2009). Quasi-experiments and hedonic property value methods. *Available at SSRN 1283705*.

Paterson, R. W., & Boyle, K. J. (2002). Out of sight, out of mind? Using GIS to incorporate visibility in hedonic property value models. *Land economics, 78*(3), 417-425.

Pope, J. C. (2008). Buyer information and the hedonic: the impact of a seller disclosure on the implicit price for airport noise. *Journal of Urban Economics, 63*(2), 498-516.

Poudyal, N. C., Hodges, D. G., Tonn, B., & Cho, S.-H. (2009). Valuing diversity and spatial pattern of open space plots in urban neighborhoods. *Forest Policy and Economics, 11*(3), 194-201. doi: 10.1016/j.forpol.2009.02.007

Powe, N. A., Garraod, G., Brunsdon, C., & Willis, K. (1997). Using a geographic information system to estimate an hedonic price model of the benefits of woodland access. *Forestry, 70*(2), 139-149.

Randall, A. (1998). Beyond the crucial experiment: mapping the performance characteristics of contingent valuation. *Resource and Energy Economics, 20*(2), 197-206.

Redfearn, C. L. (2009). How informative are average effects? Hedonic regression and amenity capitalization in complex urban housing markets. *Regional Science and Urban Economics, 39*(3), 297-306.

Rogers, G. O., & Bardenhagen, E. K. (2013). Valuing ecological resources through stakeholder participation. *Open Journal of Ecology, 3*(05), 343.

Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. [Article]. *Journal of Political Economy, 82*(1), 34.

Saaty, T. L. (1990). How to make a decision: the analytic hierarchy process. *European journal of operational research, 48*(1), 9-26.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences, 1*(1), 83-98.

Sakia, R. (1992). The Box-Cox transformation technique: a review. *The statistician*, 169-178.

Samuelson, P. A. (1954). The pure theory of public expenditure. *The Review of Economics and Statistics, 36*(4), 387-389.

Saphores, J. D., & Li, W. (2011). Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA. *Landscape and Urban Planning*.

Shannon, C. E., & Weaver, W. (1949). The mathematical theory of communication (Urbana, IL. *University of Illinois Press, 19*(7), 1.

Simons, R., & Salling, M. (1995). Using GIS to make Parcel-based real estate decisions for local government: a financial and environmental analysis of residential lot redevelopment in a Cleveland neighborhood. *URISA Journal, 7*(1), 7-19.

Slocombe, D. S. (1993). Environmental planning, ecosystem science, and ecosystem approaches for integrating environment and development. *Environmental Management, 17*(3), 289-303. doi: 10.1007/bf02394672

Tabachnick, B. G., & Fidell, L. S. (2001). Using multivariate statistics.

Taff, S. J., Tiffany, D. G., & Weisberg, S. (1996). Measured effects of feedlots on residential property values in Minnesota: A report to the legislature: University of Minnesota, Department of Applied Economics.

Tapsuwan, S., Ingram, G., Burton, M., & Brennan, D. (2009). Capitalized amenity value of urban wetlands: a hedonic property price approach to urban wetlands in Perth, Western Australia*. *Australian Journal of Agricultural and Resource Economics, 53*(4), 527-545. doi: 10.1111/j.1467-8489.2009.00464.x

TheĻriault, M., & Des Rosiers, F. (2004). The impact of surrounding land use and vegetation on single-family house prices. *Environment and Planning B: Planning and design, 31*, 539-567.

Thorsnes, P. (2002). The value of a suburban forest preserve: Estimates from sales of vacant residential building lots. *Land economics, 78*(3), 426-441.

Tong, C., Feagin, R. A., Lu, J., Zhang, X., Zhu, X., Wang, W., & He, W. (2007). Ecosystem service values and restoration in the urban Sanyang wetland of Wenzhou, China. *Ecological Engineering, 29*(3), 249-258. doi: 10.1016/j.ecoleng.2006.03.002

Triplett, J. E. (1991). *Hedonic methods in statistical agency environments: an intellectual biopsy.* Paper presented at the Fifty years of economic measurement: the jubilee of the conference on research in income and wealth.

Tyrväinen, L. (1997). The amenity value of the urban forest: an application of the hedonic pricing method. *Landscape and Urban Planning, 37*(3), 211-222.

Tyrväinen, L., & Miettinen, A. (2000). Property prices and urban forest amenities. *Journal of environmental economics and management, 39*(2), 205-223.

Ulrich, R. S. (1979). Visual landscapes and psychological well-being. *Landscape Research, 4*(1), 17-23.

Ulrich, R. S. (1986). Human responses to vegetation and landscapes. *Landscape and Urban Planning, 13*, 29-44.

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. *The biophilia hypothesis*, 73-137.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of environmental psychology, 11*(3), 201-230.

Vilkka, L. (1997). *The intrinsic value of nature* (Vol. 59): Rodopi.

Wilson, E. O. (1984). *Biophilia*: Harvard University Press.

Wolf, K. L. (2005). Trees in the small city retail business district: Comparing resident and visitor perceptions. *Journal of Forestry, 103*(8), 390-395.

Wooldridge, J. M. (1992). Some Alternatives to the Box-Cox Regression Model. *International Economic Review, 33*(4), 935-955.

Wooldridge, J. M. (2009). *Introductory econometrics: A modern approach*: South-Western Pub.

Yli-Pelkonen, V., & Kohl, J. (2005). The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. *Sustainability: Science, Practice, & Policy, 1*(1).

APPENDIX 1

REVEALED PREFERENCE METHODS AND STATED PREFERENCE METHODS

1.1 Revealed Preferences Methods

Revealed preference methods obtain demand and value information of private goods to explain changes or differences in the quantities and/or qualities of non-market goods (Freeman Iii, 2003). The methods assume that the preferences of consumers can be revealed by their market behavior. The value of non-market goods, including ecosystem and its services, is estimated from observations of consumers' behavior in the markets for related goods that have monetary values imposed (Freeman Iii, 2003; Heal, 2000). Consumer behavior includes how people purchase goods, select one over another, and pay discriminately according to the conditions of goods. Such market transactions for the related private goods can be used to infer the demands for environmental services (Freeman Iii, 2003). In the process of revealing relationships between consuming behavior of private goods and value of environmental services, it becomes important to investigate not only the evidence of economic activities but also the circumstantial conditions of both private and public goods in order to comprehend the values individuals place on such services.

1.1.1 Travel Cost Method

Travel cost method estimates the value of environmental resource by investigating cost and time people spend to visit a site that allows them to engage/enjoy/access a particular resource. The method is based on observed market behavior, in this case travel behavior, to statistically estimate a demand curve for visiting the site or enjoying the recreational opportunities the site offers (Freeman Iii, 2003). The time and cost expenses of the travel represents the price to access the site. With the price, the model estimates the additional amount a visitor would pay for visiting the site (Loomis, 2000). The rudimentary premise that increase in travel distance will decrease the number of trips to the site, is the basis for willingness to pay to visit the site. The method estimates the monetary value of the resource with the number of trips people make at different travel costs (Loomis & Walsh, 1997). In reality, the site will have different visitors from different locations. Spatially varying prices can be observed by investigating the number of trips taken with variations in travel costs to the site. Using this data on travel costs and number of trips taken for certain periods, the demand curve can be estimated by multiple regression (Loomis, 2000). Travel cost method can also be applied to measure the demand shifts for improved conditions of a resource. Improved water quality of wetland might incur an increase in visitation. The demand shift can be estimated by observing how the number and cost of visitation changes with improvement in the conditions of the resource. From the shift, additional price a visitor would pay for improved water quality of the wetland can be derived (Loomis, 2000).

For travel cost method to reveal an accurate estimate of the benefits a resource provides, some assumptions are required. The trip to the site must be a single destination trip. The model cannot account for multi destination trip, of which the cost of each trip cannot be precisely allocated. In addition, there should be no benefits from the travel other than visiting the site. Cost of the travel and travel time are obliged to be spent exclusively for gaining access to the site, not for other purposes, such as meeting friends, conducting business or sightseeing during the travel. In other words, the primary purpose should be visiting the site, not multi-purpose sightseeing. Often times, TCM will overstate the value of the site by including benefits derived from sightseeing in the course of the trip. Another assumption is that there needs to be sufficient variation in travel costs to estimate the demand curve. If there is little variation in travel cost, the demand curve fitted will likely be inaccurate (Freeman Iii, 2003; Loomis & Walsh, 1997). When those assumptions are met, TCM provides relatively accurate estimation since the method is based on the behaviour of people (Loomis & Walsh, 1997). However, there are some problems associated with TCM. TCM cannot be applied to environmental services that have visitors with little variation in travel cost and time. Urban parks and recreation sites usually have visitors with same travel cost, often times close to zero. In these cases, CV will estimate more accurate measures (Loomis & Walsh, 1997). Another issue is related to converting time into monetary value. In the process of TCM estimation, time, an important variable in the analysis, is converted into shadow price, which is often estimated from a model that explains the choices made regarding the use of time. Several models of choice and time are available but they seem to produce different estimates of the shadow price of time. There is no clear basis to choose which model for each given condition (Freeman Iii, 2003).

1.1.2 Hedonic Pricing Model

Hedonic pricing model estimates the implicit prices of the characteristics of a composite good using its various intrinsic and environmental attributes of the subject (Can, 1990, 1992; Freeman Iii, 2003; Rosen, 1974). The method derives monetary values from the characteristics that differentiate each product among other closely related products. The characteristics of a good that please consumers are examined using observed price data of related goods, which reveals consumers' preference. This method is widely used with houses and surrounding environments to measure how much of the variation in each characteristic, which includes the surrounding environment, explains the variation in house prices (Heal, 2000). In other words, HPM explains the prices of houses within a single market boundary as a function of its various intrinsic and environmental attributes embedded in each unit of property(Freeman Iii, 2003). In cases of environmental valuation, the model requires information on house prices along with characteristics of the house and the surrounding land to infer the value of environmental amenities. For example, to fully comprehend a house, we need to investigate structural features such as number of bedrooms and bathrooms, backyard, front yard, garage, and square footage. In addition to structural features, the condition of a house is also closely related to structure and characteristics of neighborhood, community, and surrounding environment. It is logical to state that the features and characteristics enumerated above influences the price of the house.

Despite the method's relatively accurate measures of implicit price of residential attributes, there are several limitations and assumptions required. First, theoretically, the housing market should be in or near to equilibrium. This implies that homebuyers are fully aware of property prices of alternative conditions and locations and make most reasonable choices. In an efficiently operating housing market, both buyers and sellers share comprehensive knowledge of related properties in terms of its structural, neighborhood, locational, and environmental attributes(Freeman Iii, 2003; Hanley, 1992; McConnell & Walls, 2005). Second, the valuation should be conducted within a single housing market. Considering the various intrinsic and environmental attributes embedded in each house, subjects being examined should remain in relatively compact and homogenous study sites. Even with the assumptions satisfied, there still are limitations in HPM. The method cannot capture the impact of long-term subtle changes associated with reduced environmental quality because residents can only perceive differences in amenities and their consequences for a short period of time (Freeman Iii, 2003). Being based on property values, HPM fails to account for the benefits, which includes use and non-use values, derived by non-local users of a resource, who do not live close to the site (More et al., 1988). Thus, economic benefits of remote resources or resources with large service areas cannot comprehensively be computed. Lastly, the method makes use of current house prices to make assumptions of future environmental quality level (Hanley, 1992). Since it uses present levels of the amenities in the calculation, people might wrongly expect future levels of those amenities to remain constant which does not account for potential changes.

In addition to the limitations and assumptions required, there are several methodological issues that need to be addressed. The issues will be listed here and detailed discussion will be pursued in later chapters. The issues include identification problems, measurement and data procurement, the choice of functional form, the extent of the market under study, spatially autocorrelated errors, omitted variables problem, and multi-collinearity (Bockstael & McConnell, 2007; Hanley, 1992).

Hedonic pricing models are useful for estimating the value of nonmarket environmental amenities and disamenities, such as parks, open space, air pollution, noise, and proximity to noxious facilities (McConnell & Walls, 2005). Despite the limitations, issues, and assumptions required, the method has been shown to be a legitimate measure to value environmental resources, as F. Des Rosiers et al. (1996) notes “HPM has proven most reliable for establishing the implicit price of individual residential attributes.".

1.2 Stated Preference Methods

Stated preference methods use data from people’s responses to hypothetical questions rather than observations of individual choices. The methods have an advantage over revealed preference methods on circumstances where market behavior cannot be observed or market is in disequilibrium (Freeman Iii, 2003). Loomis and Walsh (1997) also emphasized the methods’ ability to measure a much broader range of values associated with many more types of resources than reveal preference methods. Since the method infers values from stated responses to hypothetical questions of alternative situations, it can be flexibly used to estimate the economic value of virtually anything. In this sense, Freeman Iii (2003) defines stated preference methods as "any survey-based study in which respondents are asked questions that are designed to reveal information about their preferences or values." Depending on the types of questions asked, whether it directly asks monetary values or not, the method either belongs to (1) contingent valuation method (2) contingent choice or (3) the behavioral method.

1.2.1 Contingent Valuation Method

Contingent valuation method is a survey-based valuation technique for non-market resources. It involves asking people monetary values for a specified change in an environmental amenity. The maximum amount of willingness to pay for an event to occur is surveyed to estimate demand like relationship, from which the sample average WTP is calculated (Freeman Iii, 2003; Heal, 2000; Loomis, 2000). CVM can be used to estimate both use and nonuse values (Loomis, 2000). Use values mainly refer to recreational opportunities and nonuse values refer to existence and bequest values. Existence value reflects satisfaction from knowing that the resource exists and bequest value reflects willingness to pay to protect the resource for future generation (Loomis & Walsh, 1997).

There are several types of questions being used in CVM. Open-ended questions are made with iterative technique, essentially a bidding game. A respondent is asked of their willingness to pay with a certain amount and if the answer is yes, the question is repeated with higher amount until the answer becomes no. The highest price to which the respondent agreed is interpreted as the maximum WTP. The process goes the other way when the answer is no until the respondent answers yes. The problem with this approach is that the outcomes are influenced by the starting price of the questionnaire, starting point bias (Freeman Iii, 2003). An alternative approach to this is simply asking the amount respondents are willing to pay. However, this technique exposes the respondents with unfamiliar problems which they do not have any clue to pose a value on them. This results in high rates of nonresponses or high proportions of extremely high or low stated values (Freeman Iii, 2003). Another technique utilizes cards with a range of alternative payment values and asks the respondents to pick a card or state their own value if the value is missing. (Freeman Iii, 2003)

To overcome some problems associated with above question types, researchers have developed another question technique that attempts to minimize the issues. This other question type is discrete Choice. It asks whether the respondents would be willing to pay a specified amount to obtain the environmental change. Respondents are assigned randomly to different subsamples of which each asks different amount of WTP (Freeman Iii, 2003). The premise of this approach is that the proportion of yes responses decreases as the price increases. This questionnaire shares a relatively familiar social context since people always compare price options and decide whether the product has that much value or not. The question requires simple decision for respondents. Because of this nature, discrete choice surveys usually have low non response items and fewer refusals to participate in the survey. It also minimizes the respondents opportunities to overstate their valuation for their favor (Freeman Iii, 2003; Loomis & Walsh, 1997).

Despite the method's advantage of wide application range with relatively limited data, CVM is criticized for number of reasons. The major issue is whether CVM can accurately measure economic values or not (Boxall, Adamowicz, Swait, Williams, & Louviere, 1996). There is a huge gap between answering for the amount of willingness to pay and the actual payment. In most cases, respondents will answer significantly greater willingness to pay amount than what he/she would actually pay. Generally respondents are more generous with "monopoly money" since there is no harm to overestimating willingness to pay in a hypothetical situation (Heal, 2000; Mundy & McLean, 1998). For a similar reason, respondents might seek a sense of satisfaction from the feeling of giving to a greater good. This "warm glow" phenomenon is another potential problem respondents would cause unconsciously (Mundy & McLean, 1998). It is also possible to have the opposite problem, protest responses, where respondents answer zero willingness to pay due to their personal reasons, like disagreeing with the direction and concept of the improvement and not believing the method of payment listed to be equitable. In those cases, protest answers should be distinguished from true zero valuations. In addition, the characteristics of a public good, people taking advantage of free-riding, distracts respondents to value a resource objectively. People would not voluntarily contribute to the good, if others will pay and provide the service for them (Loomis & Walsh, 1997; Randall, 1998; Samuelson, 1954). As mentioned before, stated willingness to pay is often sensitive to the format of the question and to the payment methods and periods (Loomis, 2000).

In addition to the above concerns, these factors could potentially influence CVM responses; bid design and starting points; strategic behavior; order effects; scope effects or embedding; interviewer influence; survey response rates and nonresponse bias; and, effects of survey mode (Loomis & Walsh, 1997; Mundy & McLean, 1998). For CVM studies, it is the most critical to design survey questions carefully for results to have degree of validity (Freeman Iii, 2003; Heal, 2000).

1.2.2 Contingent Experiment Choice and Conjoint

The choice experiment or conjoint analysis method of estimating values asks respondents to select their most preferred option or to rank or rate hypothetical alternatives of different sets of environmental attributes in order of preference. Each alternative has several attributes of which one is a monetary dimension (Boxall et al., 1996; Freeman Iii, 2003). Contingent conjoint method is essentially similar to contingent experiment choice method except that it asks respondents to place a value or rank on each attribute (NationalResearchCouncil, 2005). It is a joint method of contingent valuation and contingent experiment choice, which many analysts consider as CE in a broader perspective (Batsell & Louviere, 1991; Freeman Iii, 2003).

CE method involves experimental alternatives to represent respondents' judgments of multi-attribute stimuli (Batsell & Louviere, 1991). To be more specific, the method provides respondents with a set of hypothetical alternatives of different sets of attributes. Respondents are asked to rank the alternatives or to pick the most preferred alternative. These choice answers reflect trade-offs among attributes, which reveal the marginal rates of substitution between attributes. Using one of the attributes that have monetary value and the marginal rates between attributes, the respondent's willingness to pay for the good can be measured (Freeman Iii, 2003). Since CE asks respondents to choose different sets of attributes, of which possible combination to formulate alternatives is infinite, research designers should be extremely careful in developing the relevant alternatives with appropriate attributes (Adamowicz, Boxall, Williams, & Louviere, 1998).

The CE method has several advantages over CVM. First of all, it is easier for respondents to rank alternatives ordinally than impose a monetary value on nonmarket goods, which makes the result more reliable if the design was carefully devised (Freeman Iii, 2003). In addition, value of attributes and each alternative can be inferred in this attribute based CE approach. It also provides more detailed description of tradeoffs within each attribute and alternative by examining attributes and levels of specific choice situations. Furthermore, since marginal rate is calculated in CE process, compensating amounts of other goods can be calculated when a particular attribute is damaged (Adamowicz et al., 1998; Boxall et al., 1996). Statistical advantages of CE over CVM are also emphasized in many studies (Adamowicz et al., 1998; Boxall et al., 1996).

It is possible to conduct multi-attribute evaluation by CVM. A researcher can take an extremely burdensome approach in which a large number of CVM type questions are repeatedly asked to respondents to draw tradeoffs among attributes.

However, the essence of this difficulty also exists in CE methods since CE presents similar types of questions (Adamowicz et al., 1998). The challenges are to control the experimental conditions, determine what conditions are, and to provide an appropriate interpretation of the results (Freeman Iii, 2003). Information provision, and survey administration is also an important issue in CE approach (Adamowicz et al., 1998).

1.2.3 Analytic Hierarchy Process

Analytic hierarchy process measures the relative preference of one attribute over another attribute through pairwise comparisons by which trade-offs in non-quantifiable, nonmarket attributes are revealed (Duke & Aull-Hyde, 2002; Saaty, 2008). After these trade-offs are converted into ratio-scale weights for each attributes, all the weights are added to the associated alternatives, to create priority scales for each alternative (Forman & Gass, 2001). In many cases, AHP conducts surveys of experts and relies on their judgments for priority scales (Saaty, 2008). AHP is useful for complex problems, involving human perceptions and judgments. It arranges the goals, attributes, issues, and stakeholders in a hierarchy and generates relative ratio scales for each attribute and alternatives. This provides an overall view of the complex relationships even with elements that are difficult to quantify and compare (Saaty, 1990). Since the process reveals general priority scales and relative ratio scales for each attribute, AHP can be used in a group decision making process where communication among stakeholders is impeded by their different specializations or perspectives.

AHP is relatively simple process. The method does not use statistical analysis and the results are presented in intuitive manner, thus easily interpreted. In addition, AHP does not require a large sample size. Theoretically, the process can be performed with a single survey sample (Duke & Aull-Hyde, 2002). However, for this reason, it is criticized for the inconsistency in the judgments (Saaty, 2008). The priority scales can be biased depending on the sample size and characteristics of respondents. Another issue with AHP involves a phenomenon called rank reversal. In AHP, the rank between existing alternatives changes when a new alternative is introduced to the decision problem. Some decision theories do not allow this rank reversal to occur. In course of development of the AHP theory over 30 years, researchers have developed means to deal with the rank reversal by categorizing conditions where it is allowed and where it is not (Forman & Gass, 2001).

AHP can be used along with other measures that value environmental resources based on attribute tradeoffs. The results from AHP provide a more detailed understanding of attributes of a resource, which can be added to results derived from contingent valuation or contingent experiment choice valuation to supplement and enhance complete understanding of the value of the resource. The results of AHP on the relative importance of the attributes can be compared with CV's results of the overall benefits and adjudge the validity of those results (Duke & Aull-Hyde, 2002).

1.2.4 Cost-based Methods

Cost based methods include replacement cost, damage cost avoided, and substitute cost methods. These methods economically value ecosystem services or environmental resources based on the cost of replacing, avoiding damages, or providing substitute services in a single dimension of the service related. This is based on the assumption that the resource is worth at least the cost to replace them. However, this method cannot account for holistic measures of economic value of a resource providing infinite number of services in ecosystem (Heal, 2000). It can only replace or substitute a single function among many others that the resource performs. The water purification services of a wetland can be monetarily valued by measuring the cost of filtering and chemically treating water. However, it will be impossible to value all the services that the wetland provides, which includes but not limited to biodiversity, recreation and tourism, cultural values, and climate change mitigation.

This method is relatively easy and the process and outcome are intuitive. Revealed preference and stated preference methods require intensive amount of data, resource, and even intelligent manpower to conduct the methods and interpret the results. On the other hand, these methods are straightforward and less intensive. Its intuitive results are more effective for public to understand the value of a resource. Even though, the methods can only measure a single dimension of the service, it provides surrogate measures of value that is consistent. Technically, the cost derived from these methods is as accurate as it can be. Despite these advantages, the methods hold numerous limitations and shortcomings to measure value of environmental services.

First of all, benefits cannot be accurately reflected by costs. The method only measures cost for a single dimension of the services. Also, deciding the degree of quality and quantity of the substitution is another difficult task when the service is replaced or substituted. Finally, the methods cannot account for social preferences and individual behavior, which are the most important factors of valuing goods and services.

APPENDIX 2

METRICS AND MEAURES USING GIS

2.1 Area and Pattern

Along with the access and visibility assessment, use of GIS also facilitated analyzing process of area and pattern of the surrounding landscapes. The simplest measure of area and pattern is calculating size and shape of the dis/amenity of the area. Mahan et al. (2000) used such variables in an attempt to examine the influence of wetland amenities on nearby residential areas. In more advanced attempts, landscape composition metrics and landscape configuration metrics, grounded in the landscape ecology literature, have been developed using GIS and FRAGSTAT.

2.2 Landscape Composition Metrics

Landscape composition metrics describe the relative coverage for each land use. These metrics can usually be calculated by GIS. During the process of measuring the metrics, spatial land use/cover variables are used to develop the percentage of the area occupied by different land use/coverage, consisting of residential, commercial, agriculture, forest, and surface water, within a certain radius around each property. The percentage of area visible overall and in each land use/cover within same radius is also measured (Kong et al., 2007; Palmer, 2004; Paterson & Boyle, 2002). In order to develop such metrics, digitized land-use data is required. When such data is not available, aerial photographs and a Landsat image can be used in GIS to prepare the data. In producing land-use data with aerial photographs and a Landsat TM5 image, aerial-photograph mosaic is categorized manually in GIS. The area is divided into polygons by the road network and manual classification, which then is coded with the main land-use type (TheĻriault & Des Rosiers, 2004).

2.3 Landscape Configuration Metrics

Landscape configuration metrics, developed by landscape ecologists utilizing GIS techniques, include the pattern of surrounding land uses, measures of percent open space, diversity, and fragmentation of land uses(Jacqueline Geoghegan et al., 1997; Palmer, 2004). More specifically, it expands but not limited to largest patch index, patch density, edge density, landscape shape index, patch richness index, and Shannon's evenness index(Jacqueline Geoghegan et al., 1997; Palmer, 2004). Those indices are calculated by FRAGSTATS.

When the focus of the research is vegetation and green space, landscape spatial indices including percentage of urban green space, patch richness of urban green space, number of green space patches, aggregation of urban green space, patch richness of land-use, number of patches of land-use can be computed with FRAGSTATS. A "moving window" analysis in FRAGSTATS captures these landscape metrics with window sizes of 300 and 500m radius. The analysis allows the composition indices to be spatially referenced and visualized. With the resulting data from FRAGSTATS analysis, quantitative data of landscape indices are calculated using a sampling tool in the GIS spatial analysis module (Kong et al., 2007). In addition to the indices produced by FRAGSTATS, normalized difference vegetation index (NDVI) can be calculated.

The index ranges from 1 to -1, higher value indicating higher density of green leaves (TheĻriault & Des Rosiers, 2004).

In open space valuation, diversity index, mean patch fractal dimension, and plot density measure are emphasized. The diversity index can be measured in several separate indices in accordance with the variables of the research emphasis (Poudyal et al., 2009). For example, one diversity index can be calculated for open space and the other for developed land-use. The diversity indices are calculated as,

$$\mathrm{DI_n} = -\sum_{l} p_l \cdot \ln p_l$$

where, $\mathrm{DI_n}$ is the diversity index in nth neighborhood, and p_l is the proportion of land use type l in undeveloped or developed space. The index represents the dominance by few or many land use types in the neighborhood and depends on the diversity and the evenness of the land use distribution. A large index value can be interpreted as a greater diversity (G. Acharya & L.L. Bennett, 2001; Jacqueline Geoghegan et al., 1997).

The open space mean plot fractal dimension(MPFD), developed from the concept of habitat mean patch fractal dimension from landscape ecology (McGarigal & Marks, 1995) is used to capture the shape complexity of the open space plots. The open space mean plot fractal dimension (MPFD) is computed as,

$$MPFD_n = \sum_{i=1}^{m} \frac{2\ln B_i}{\ln A_i} / m$$

where, $MPFD_n$ is the mean plot fractal dimension of open spaces in neighborhood n; B_i and A_i are respectively the perimeter (boundary length) and area of the ith plot in neighborhood n; m is the total number of distinct open space plots in the nth neighborhood. A fractal dimension is an index for characterizing fractal patterns and quantifying their complexity by comparing how detail a pattern changes with the scale at which it is measured. MPFD greater than 1 for a 2-dimensional landscape mosaic indicates an increase in patch shape complexity. MPFD value close to 1 represents a neighborhood containing open space plots with simple perimeters, such as circles or squares, and MPFD value close to 2 indicates a neighborhood containing open space plots with highly convoluted, plane-filling perimeters (Poudyal et al., 2009).

A plot density is measured to capture the spatial heterogeneity of open space distribution within neighborhood. The plot or patch density expresses the number of distinct open space plots within the entire reference area per hectare (McGarigal & Marks, 1995). Plot density, calculated by total number of patches divided by the area, increases with a greater number of plots within a reference area. Thus, a higher plot density may represent a more fragmented pattern (Nelson et al., 2004).

2.4 GIS in Other Research Areas

Tong et al. (2007) conducted a study investigating structural indices and a valuation of the wetland's ecosystem services for the future restoration work in the Sanyang wetland, China. Information on land-use and vegetation change was acquired by importing 2002 Landsat images into GIS applications, ArcView3.2a and Mapinfo 6.0. The image data was classified into four classes, water, tree orchards, residential areas, and other farm areas, with the default Natural Breaks Classification in ArcView. To minimize the error, Global Positioning System was used in the process of ground-truthing. Upon the completion of image processing, the abiotic and biotic components were surveyed from samples at each survey site. With the spatial data from GIS and surveyed data from samples, the authors estimated the biophysical value of each basic service the wetland provides.

Recent rapid imagery technology advance provided researchers with sophisticated means to acquire more accurate geographical data of the study sites. Feagin, Martinez, Mendoza-Gonzalez, and Costanza (2010) utilized Iterative Self-Organizing Data Analysis Technique of ENVI image process software to classify zones in 2005 Color Infra-Red(CIR) image of the study area. After classification, Ground truthing from Global Positioning System (GPS) was used to correct positional error, and LIDAR laser-altimetry dataset were overlaid to define the elevation ranges of each zone. The authors created an algorithm to be utilized in model builder of ArcGIS. The model analyzed LIDAR data for every 0.01m in the vertical dimension and measured the frequency of occurrence of each classified zone across elevation in the NAVD 88 vertical datum.